HEWLETT PACKARD

Service Guide

HP 54520 and HP 54540 Series Oscilloscopes

Service Guide

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HP 54520 and 54540 Series Oscilloscopes

The HP 54520 and 54540 Series Oscilloscopes

This family of digitizing oscilloscopes provides a choice of channel count and sample rate. The HP 54522A and 54542A have two and four channels respectively and offer 500 MHz repetitive and real-time bandwidth and a 2 GSa/s sample rate. The HP 54520A and 54540A also have two and four channels respectively and offer 500 MHz repetitive bandwidth, but offer a lower maximum sample rate so less real-time bandwidth.

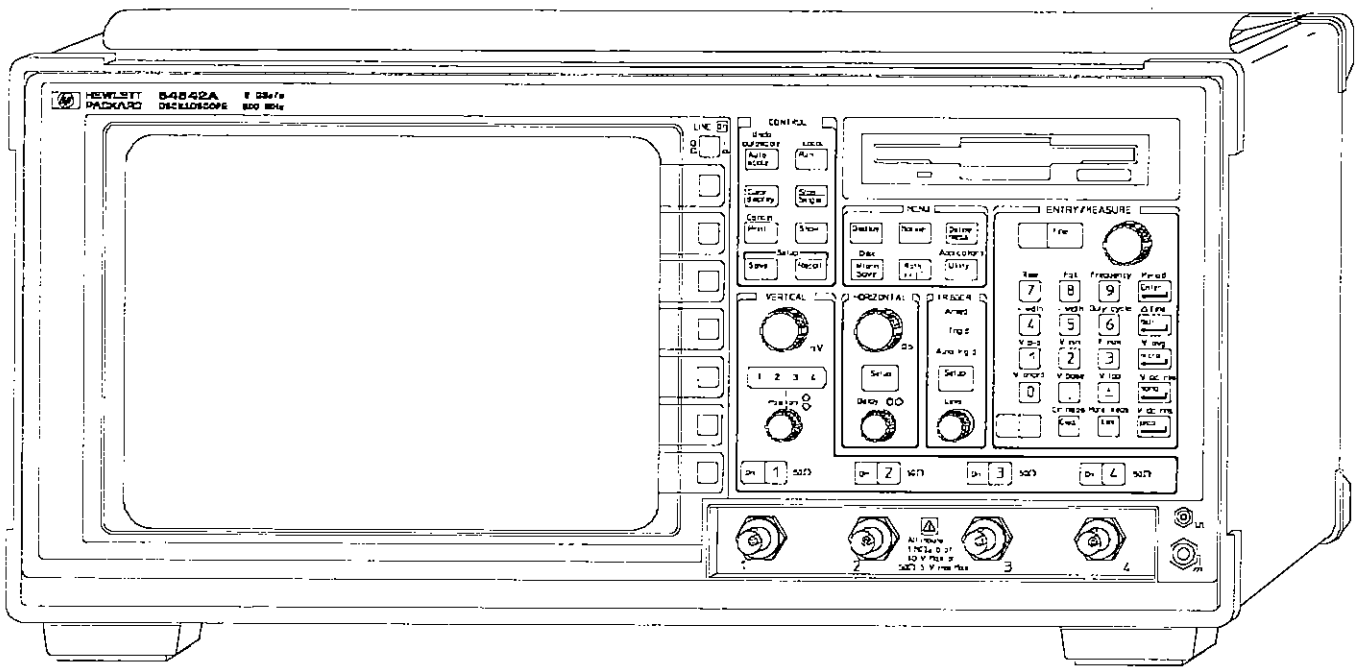
Features

This family has a variety of high-performance features:

- Two or four signal channels. Two channel models have a front panel external trigger.
- Up to 2 GSa/s sample rate
- dc to >500 MHz repetitive (equivalent time) bandwidth
- Dedicated knobs for vertical, horizontal, and trigger functions
- 32 Kbytes of memory per channel
- 1 mV to 5 V/div channel sensitivity
- Selectable 50-Ω or 1-MΩ input resistance on channels and external trigger
- Sweep speeds from 500 ps/div to 5 s/div
- Internal and external trigger to >500 MHz
- Auxiliary trigger to >50 MHz
- Autoscale
- 23 automatic pulse parameter measurements
- Time tagging of sequential single-shot acquisitions
- Easy waveform storage
- 1.44-Mbyte disk drive
- Full programmability over HP-IB
- Connections for hardcopy output

Service Policy

The service policy of this instrument requires replacing defective assemblies. Some assemblies can be replaced on an exchange basis.


HEWLETT PACKARD
54542A
DSCILLOSCOPE
CONTROL
MENU
ENTRY/MEASURE
VERTICAL
HORIZONTAL
TRIGGER

54542E24

In This Book

This book provides the service documentation for the HP 54520 and 54540 series oscilloscopes. It is divided into eight chapters.

Chapter 1 provides general information and specifications.

Chapter 2 shows you how to prepare the oscilloscopes for use.

Chapter 3 gives performance tests.

Chapter 4 covers calibration and adjustment procedures, how to do them, and how often they need to be done.

Chapter 5 provides troubleshooting information.

Chapter 6 gives the procedures and techniques for replacing assemblies and other parts.

Chapter 7 includes a list of exchange assemblies and other replaceable parts, part ordering information, and shipping information.

Chapter 8 briefly covers the internal operation of the oscilloscopes.

At the back of the book you will find Safety information, Warranties, and Regulatory information.

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1

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General Information

General Information

This chapter of the Hewlett-Packard 54520 and 54540 series oscilloscopes service guide gives you general information about the instrument. The following topics are covered in this chapter.

- Instrument identification
- Accessories
- Options
- Specifications and characteristics
- Test equipment requirements

Accessories Supplied

The following accessories are supplied.

- HP 10441A miniature passive probes (four with the HP 54540A and 54542A, two with the HP 54520A and 54522A)
- One 2.3-meter (7.5-ft) power cord (See chapter 7, "Replaceable Parts," for available power cords)
- One set of User's and Programmer's Guides
- One Service Guide

Accessories Available

The following accessories are available for use with these oscilloscopes.

- HP 10441A 10:1 1 MΩ probe (2m)
- HP 10430A 10:1 1MΩ probe (1m)
- HP 10438A 1:1 probe (1m)
- HP 10439A 1:1 probe (2m)
- HP 10002A 50:1 1 MΩ (1000 V peak) probe
- HP 10437A 1:1 50 Ω probe (2m)
- HP 10442A 10:1 500 Ω probe (for 50 Ω inputs, 2m)
- HP 10443A 20:1 1000 Ω probe (for 50 Ω inputs, 2m)
- HP 10020A Resistive Divider Probe Kit
- HP 10450A SMT probe accessory kit
- HP 1144A 800 MHz Active Probe
- HP 01144-61604 1:2 probe power fan-out

- HP 1141A/1142A Differential Probe system
- HP 54701A 2.5 GHz/0.6 pF Active Probe (need HP 1143A probe power)
- HP 1137A 1000:1 High voltage divider probe
- HP 1133A TV/Video Sync Pod
- HP 10211A 24-pin IC Clip
- HP 10024A 16-pin IC Clip
- HP 1250-1454 BNC to Miniature Probe Adapter
- HP 1250-2427PC Board Mini-Probe Socket (horizontal mount)
- HP 1250-2428 PC Board Mini-Probe Socket (vertical mount)
- HP 10240B BNC Blocking Capacitor
- HP 11094B 75Ω Feedthrough Termination
- HP 5062-7379 Rack Mount Kit
- HP 1494-0015 Rack Mount Slide Kit
- HP 1540-1066 Soft Carrying Case
- HP 1180A Tilt-tray Testmobile
- HP 92199B Power Strip for test mobile
- HP 2227B QuietJet
- HP 92203J HP-IB to Centronics converter
- MicroPrint 45CXA HP-IB to Centronics converter
- HP 7440A (Option 002) Color Pro plotter
- HP 7475A (Option 002) plotter
- HP 7550B (Option 005) plotter

Options Available

The following options are available for these oscilloscopes.

- Option 910 — Additional User's and Programmer's Guide Set, and Service Guide
- Option 090 — Deletion of probes
- Option 908 — Rackmount kit
- Option 1BN — MIL-STD Certification. Product calibration certificate in compliance with MIL-STD-45662A.
- Option 1BP — MIL-STD Certification with data. Product calibration certificate and performance test data report in compliance with MIL-STD-45662A.
- Option +W50 — Two additional years (five years total) of return-to-HP service.
- Option +W52 — Five years of HP Calibration service at an HP service center.

Other options are available. See your HP sales representative.

Specifications

The specifications are listed below. Specifications are valid after a 30 minute warm-up period.

Vertical

Bandwidth (–3dB, dc coupled)

Repetitive (all models) dc to ≥500 MHz (equivalent time)

Real Time

HP 54520A dc to ≥125 MHz

HP 54522A dc to ≥500 MHz

HP 54540A dc to ≥125 MHz (3 or 4 CH on), dc to ≥250 MHz (1 or 2 CH on)

HP 54542A dc to ≥500 MHz

Rise Time [1]

Repetitive (all models) ≤700 ps

Real Time

HP 54520A ≤2.8 ns

HP 54522A ≤700 ps

HP 54540A ≤2.8 ns (3 or 4 CH on), ≤1.4 ns (1 or 2 CH on)

HP 54542A ≤700 ps

Input R (selectable) 1 MΩ ±1% or 50 Ω ±1%

Maximum Input Voltage

1M Ω ±250 V [dc + peak ac(<10 kHz)]

50 Ω 5 V_{rms}

Offset Accuracy [2] ±(1.25% of channel offset + 2% of full scale)

Voltage Measurement Accuracy (dc) [2,3]

Dual Cursor ±[1.25% of full scale + (0.032)(V/div)]

Single Cursor ±[1.25% of full scale + offset accuracy + (0.016)(V/div)]

Time Base

Delta-t Accuracy

Repetitive (≥8 averages) ±[(0.005% × delta-t) + (0.1% of full scale)+ 100 ps]

Real Time [4] ±[(0.005% × delta-t) + (0.2 × sample period)]

Peak Detect ±[(0.005% × delta-t) + 1 sample period]

Trigger

Sensitivity [2]

	dc to 100 MHz	100 MHz to 500 MHz
Internal	0.5 division	1.0 division
External (HP 54520A/54522A)	0.0225 × signal range	0.045 × signal range

Auxiliary dc to 50 MHz, 250 mVp-p

Maximum Input Voltage

External Trigger (HP 54520A and 54522A)
1M Ω ±250 V [dc + peak ac(<10 kHz)]
50 Ω 5 V_{rms}
Auxiliary Trigger ±15 V

Notes:

1 Rise time figures are calculated from: tr = 0.35/Bandwidth.

2 Magnification is used below 7 mV/div range so the vertical resolution and accuracies are correspondingly reduced. Below 7 mV/div, full scale is defined as 56 mV.

3 The voltage measurement accuracy decreases 0.08% of full scale per 0 °C from the firmware calibration temperature. This specification is valid for a temperature range ±10 °C from the firmware calibration temperature. The specification applies to both the repetitive and real time modes.

4 The specification applies for bandwidth limited signals (tr = 1.4 × sample interval). The sample interval is defined as 1/(sample rate). The specification also applies to those automatic measurements computing time intervals on pulses with identical slope edges (for example, pos-pos, neg-neg).

Performance Characteristics

The performance characteristics are listed below.

Vertical

Switchable Bandwidth Limits

ac-coupled (lower –3 dB frequency) 10 Hz
LF reject (lower –3 dB frequency) 400 Hz
Bandwidth Limit (upper –3 dB frequency) 30 MHz

Number of Channels (Simultaneous Acquisition)

HP 54520A/54522A 2
HP 54540A/54542A 4

Vertical Sensitivity Range 1 mV/div to 5 V/div

Vertical Gain Accuracy (dc)[1,2] ±1.25% of full scale

Vertical Resolution[2] 8 bits over 8 divisions (±0.4%), 10 bits over HP-IB with averaging (±0.1%)

Maximum Sample Rate

HP 54520A 500 MSa/s
HP 54522A 2 GSa/s
HP 54540A 500 MSa/s (3 or 4 CH on), 1 GSa/s (1 or 2 CH on)
HP 54542A 2 GSa/s

Waveform Record Length[3]

Real Time 32,768 points (Selectable in powers of 2: 512, 1024, 2048 . . .)
Repetitive 501 points

Input C 7 pF nominal

Input Coupling ac, dc

Offset Range

1 mV - 50 mV/div ±2 V
>50 mV - 250 mV/div ±10 V
>250 mV - 1.25 V/div ±50 V
>1.25 V - 5 V/div ±250 V

Dynamic Range ±(1.5 × full scale) from the center of the screen

Channel-to-channel Isolation (with channels at equal sensitivity)

dc to 50 MHz 50 dB
50 to 500 MHz 40 dB

Horizontal

Time Base Range 500 ps/div to 5 s/div

Time Base Resolution 10 ps

Time Tag Accuracy ±(0.005% of reading + 100 ps)

Time Tag Resolution 100 ps

Delay Range

Posttrigger 10^7 × sample period
Pretrigger 32K × sample period

Trigger

Trigger Pulse Width (minimum)

Internal and External 1 ns
Auxiliary 15 ns

Trigger Level Range

Internal ±(1.5 × full scale) from the center of the screen
External (HP 54520A and 54522A) Selectable: ±1 V, ±5 V, ±25 V
Auxiliary ±5 V

Auxiliary Input R 4 kΩ

FFTs

	HP 54520A	HP 54522A	HP 54540A	HP 54542A
Freq Range 4 dc to:	250 MHz	1GHz	250 MHz (3-4 CH) 500 MHz (1-2 CH)	1GHz
Freq Resolution				
Minimum (max samp rate)/(512 pts)	977 kHz	3.9 MHz	997 kHz (3-4 CH) 1.95 MHz (1-2 CH)	3.9 MHz

Maximum (minimum sample rate)(32768 points): 0.305 mHz (all models)

-3 dB Frequency Range dc to 500 MHz (analog bandwidth)

Frequency Accuracy $\pm\left[\frac{sample\,frequency}{2 \times number\,of\,points}\right] + (signal\,frequency \times 0.005\%)$

Spectrum Displays

Amplitude Power in dBm

Signal-to-noise Ratio 55 to 65 dB (typical). Noise floor can be reduced by increasing the number of points in the FFT.

Sensitivity Range 1 dBm/div to 100 dBm/div

Dynamic Range 55 to 65 dB (typical)

Offset Range –200 dBm to +200 dBm

Notes:

1 The gain accuracy decreases 0.08% of full scale per °C from the firmware calibration temperature. This characteristic is valid for a temperature range ±10 °C from the firmware calibration temperature.

2 Expansion is used below 7 mV/div range so vertical resolution and accuracies are correspondingly reduced. Below 7 mV/div full scale is defined as 56 mV.

3 The available waveform record length over HP-IB is 32,768 points in the real time mode and 500 points in the repetitive mode.

4 FFT amplitude readings are affected by input amplifier roll-off (-3dB at 500 MHz, with amplitude decreasing as frequency increases above 500 MHz).

Operating Characteristics

The operating characteristics are listed below.

Vertical

Deflection Factors All input channels: With a single screen selected, you can adjust deflection factors from 1 mV/div to 5 V/div in a 1-2-5 sequence with the knob. You can make fully calibrated vernier adjustments using direct keypad entry or the using the knob with Fine selected.

Probe Attenuation Factors You can enter values from 0.9 to 1000 to scale the oscilloscope for external probes or attenuators attached to the channel inputs. When probe tip calibration is performed, this value is calculated automatically. The front-panel, probe calibration source impedance is 500 Ω, so with low probe impedances, automatic calibration accuracy is dependant on the impedance of the probe.

Input Impedance 1 MΩ or 50 Ω , selectable for channels and the external trigger.

Bandwidth Limit (HF Reject) A low-pass filter with a –3 dB point at about 30 MHz for both triggering and signal display. You can select HF reject for each front-panel input individually, whether vertical or external trigger.

LF Reject A high-pass filter with a –3 dB point at about 400 Hz for the triggering and vertical signal. You can select LF reject for each front-panel input individually, whether vertical or external trigger.

ac Coupling A high-pass filter with a –3 dB point at about 10 Hz for both triggering and signal display. You can select ac coupling for each front-panel input individually, whether vertical or external trigger.

ECL/TTL Presets For ECL and TTL levels, you can preset the vertical deflection factor, coupling, offset, and trigger level independently on any vertical input channel. It is not available for the external trigger input.

Effective Resolution The maximum sample rate and the number of bits in an oscilloscope's digitizer are too often used for comparing oscilloscopes. These specifications, however, do not describe performance under dynamic signal conditions. Effective resolution is a figure of merit that describes the digitizing oscilloscope's performance under dynamic conditions, and is measured using the sine wave curve fit test. This method considers:

- Quantization error
- Nonlinearities (including preamp and ADC)
- System noise
- Frequency of input signal

All of these affect the effective resolution of the instrument. Some manufacturers specify effective bits using half-scale sinewaves. While the effective bits performance using half-scale testing is overstated when compared to full-scale testing, Hewlett-Packard publishes both sets of numbers for the oscilloscope, so that when comparing effective bits performance between digitizing oscilloscopes, a fair comparison can be made. The oscilloscope's typical performance for a single acquisition is shown below:

Frequency	50 kHz	1 MHz	20 MHz	50 MHz	100 MHz	250 MHz	500 MHz
Full scale	7.5	7.4	6.6	5.8	5.8	5.2	5.2
Half scale	7.6	7.4	7.0	6.5	6.5	5.8	5.5

For more information about effective resolution, please contact your Hewlett-Packard sales office, and ask for Product Note 5180A-2, *Dynamic Performance Testing of A to D Converters*, (pub # 02-5952-7629).

Horizontal

Pan and Zoom Changing the Time/div and/or Delay values once acquisition is stopped allows access to all captured data on each acquisition in the real-time sampling mode only.

The record length control sets the number of points (512 to 32,768) acquired with each acquisition. The auto adjust softkey allows setting the sample rate independent of the time base. The entire record length may be displayed when the oscilloscope is in the run mode.

Delay Between Channels You can null out differences in delay between channels to compensate for differences in input cables or probe length using the probe null feature.

Reference Location You can set the reference point at the left edge, center, or right edge of the display. The reference point is the trigger point plus the delay time.

Trigger

Auto Trigger Auto trigger provides an acquisition when no trigger is present. When set to auto, if the instrument does not see a trigger within about 50 ms, it will auto- matically start an acquisition. When set to trg'd, it will wait for the next qualified trigger.

Trigger Holdoff Trigger can be held off either by time or events over the ranges:

- time: 40 ns to 320 ms
- events: 2 to 16,000,000

An event is defined as the specified trigger condition. A separate holdoff setting (time or events) is available for each trigger mode except delayed trigger, which is set to 40 ns. Holdoff is not available for the auxiliary or line trigger. The maximum event counting rate is 70 MHz.

Noise Reject Reject improves triggering on noisy signals by increasing trigger hysteresis (internal trigger only). When selected, noise reject is active for all trigger modes.

Trigger Modes

Edge Trigger

You can select a positive or negative edge for trigger on any channel, the external trigger input (only on the HP 54520A and 54540A), or the auxiliary input. For the channel and external trigger sources, you can set coupling to dc, ac (10 Hz) , or lfrej (low frequency reject, 50 kHz). Trigger coupling is independent of the vertical signal coupling and noise reject. Coupling for all sources is automatically set to dc for all trigger modes except edge trigger. You can also select line trigger in the edge trigger menu.

Pattern Trigger

You can specify a pattern using any front panel channel or external trigger input. Each input can be specified as a high, low, or don't care with respect to the level setting in the edge trigger menu. The trigger can be selected to occur on the last edge to enter the specified pattern or the first edge to exit the specified pattern. The pattern must be present for more than 1.75 ns (for the channels and external trigger), before the trigger will respond.

Time Qualified Pattern Trigger A trigger occurs on the first edge to exit a pattern only if it meets the specified time criteria. The available time qualified modes are (user-specified time is in brackets):

- pattern present < [time]
- pattern present > [time]
- range: pattern present > [time1] and < [time2]

The time settings are adjustable from 20 ns to 160 ms (±3% ±2 ns). The time filter recovery time is ≤12 ns. In the "pattern present < [time]" mode, the pattern must be present for more than 1.75 ns (for the channels and external trigger), before the trigger will respond.

Glitch Pattern Trigger Pattern triggering can be used to glitch trigger in conjunction with a pattern. Using any front panel channel or external trigger input. Use "pattern present < [time]" with [time] selected, such that it is just less than the nominal pulse width of the signal you are analyzing. The minimum glitch width is 1 ns.

You can use the Glitch Trigger mode for glitch triggering on single sources with glitch widths from 1 ns to 160 ms.

State Trigger

After selecting any front panel channel or external trigger input as a clock, a pattern is specified using any of the remaining front panel inputs. The user may specify that a trigger will occur on the rising or falling edge of the input specified as the clock, when the pattern is present or not present. Setup time for the pattern with respect to the clock is 10 ns or less and hold time is zero.

Delayed Trigger

Event-Delayed Mode The trigger can be qualified by an edge, pattern, time qualified pattern, or state. The delay can be specified as a number of occurrences of a rising or falling edge of any one of the selected channels. After the delay, an occurrence of a rising or falling edge of any of the three inputs will generate the trigger. The trigger occurrence value is selectable from 1 to 16,000,000. The maximum edge counting rate is 70 MHz.

Time-Delayed Mode The trigger can be qualified by an edge, pattern, or state. The delay is selectable from 30 ns to 160 ms. After the delay, an occurrence of a rising or falling edge of any one of the selected channels or external trigger will generate the trigger. The trigger occurrence value is selectable from 1 to 16,000,000. The maximum edge counting rate is 70 MHz.

TV Trigger

60 Hz / 525 Lines Trigger source is selected to be any front-panel input. Trigger level is adjustable for the selected trigger source. Polarity is selected for positive or negative synchronizing pulses. A trigger occurs on the selected line and field of a 2/1 interlaced composite video signal. Line numbering is 1 to 263 for field 1 and 1 to 262 for field 2. This TV trigger mode is compatible with broadcast standard M.

50 Hz / 625 Lines Same as 60 Hz / 525 lines except that line numbering is 1 to 313 for field 1 and 314 to 625 for field 2. This TV trigger mode is compatible with broadcast standards B, C, D, G, H, I, K, K1, L, and N.

User-Defined Mode Source is selected to be any front-panel input. Trigger level is adjustable for the selected source. The trigger is qualified with a high or low pulse that meets a selectable time range. The trigger is an occurrence of a rising or falling edge of the source after the qualifying pulse. The time settings for the qualifier are selectable from 20 ns to 160 ms. The trigger occurrence value is selectable from 1 to 16,000,000.

NOTE: All TV trigger modes require a clamped video signal for stable triggering. Use the HP 1133A TV/Video Sync Pod to provide clamped video output that can be used in conjunction with the oscilloscope's TV triggering capabilities.

Glitch Trigger

Triggers the oscilloscope on a positive or negative glitch which is less than or greater than a selectable setting. Settings are 2.5 ns, 5 ns, 10 ns, 20, 40, 60 ns . . .. The oscilloscope will trigger on glitches from 1 ns to 160 ms. Glitch accuracy from 2.5 to 10 ns is ±1.5 ns and from 20 ns to 160 ms is ±(3% + 2 ns).

Display

Data Display Resolution 501 points horizontally by 256 points vertically.

Number of Screens You can select 1, 2, or 4 screens. This can provide overlapping channels or memories for comparison, or can provide separate displays on a split viewing area.

Screen Update Rate (typical at 500 ns/div, no measurements, and the trigger frequency is ≥50 kHz)

Real Time	**Record Length**	512	8K	16K	32K
	Updates/s	150	100	72	47

Repetitive	**Mode**	normal	8 averages	128 averages
	Updates/s	150	100	100

Display Modes

Graticules You can choose full grid, axes, frame, or no graticule.

Number of Screens On the two-channel models you can select either one or two screens. On the four-channel models you can select one, two, or four screens.

Connect-the-Dots Provides a continuous display, connecting the sample points with straight lines. Connect-the-dots is operative for modes in which a single-valued waveform can be connected, including average, envelope, single, and minimum-persistence modes. Connect-the-dots is not available in the variable or infinite persistence mode.

Time Base in the Repetitive Mode

Averaging You can specify the number of averages in powers of 2, up to 2,048. On each acquisition, $1/n$ times the new data is added to $(n\text{-}1)/n$ of the previous value at each time coordinate. Averaging operates continuously, except for the HP-IB digitize command, for which averaging terminates at the specified number of averages.

Envelope Provides a display of the running maximum and minimum voltage levels at each horizontal time position.

Minimum Persistence One waveform data value is displayed in each horizontal time position of the display. The waveform is updated as new data is acquired for a particular horizontal time position.

Variable Persistence You can vary from 500 ms to 10 seconds, the time that each data point is retained on the display, or display the points indefinitely using infinite persistence.

Time Base in the Real Time Mode

Single Persistence One waveform data value is displayed in each horizontal time position. The entire waveform is replaced with each new acquisition.

Infinite Persistence Waveform data is allowed to continuously accumulate on the screen, and remains until display is cleared.

Oversampling Filter On time/division settings when less than 500 points are acquired across the screen, a built-in digital filter automatically reconstructs the data. This filter is a combination between a (Sin X)/X and a Gaussian filter (also known as interpolation).

Peak Detect Displays the amplitude of pulses that have a pulse width of 1 ns or wider regardless of the time base setting. Peak detect works in real-time mode only at sample rates ≤250 MSa/s.

Time Base in Sequential Single-Shot

Used to view previously captured segments as defined in the time base menu. You can exclude, select, or view individual segment numbers from any channel. Viewing options include:

Normal Selection and viewing of any or all previously captured segments.

Average Averages and displays previously captured segments into a composite waveform.

Envelope Displays the minimum and maximum voltages of all previously captured segments.

Markers

Dual voltage and time markers are available. You can independently assign voltage markers to channels, memories, or functions.

Waveform Math

Four independent functions are provided for waveform math. The operators are +, −, ×, vs, magnify, inv (invert), int (integrate), and diff (differentiate), and FFT. You can use the vertical channels or any of the waveform memories for waveform math. Sensitivity and offset for these functions are adjusted independently.

Fast Fourier Transforms (FFT)

Peak Search Peak search automatically snaps cursors to any two selected peaks located anywhere in the displayed frequency span. You can select peaks from peak number 1 up to peak number 99. Frequency and dBm are automatically displayed at the bottom of the screen together with the difference in frequency between the two selected peaks. Peak search saves time by eliminating the need to manually set cursors.

Channels or Memories FFTs can be executed on any of the oscilloscope input channels, or on waveforms stored in any of four nonvolatile memories.

Variable Sensitivity and Offset Sensitivity and offset (vertical position) can be controlled to display an optimum view of the spectrum. Sensitivity is calibrated in dB per division; offset is calibrated in dBm.

Selectable Number of Points You can set the number of points the oscilloscope uses to calculate the FFT, from 512 to 32,768 (in powers of 2). Increasing the number of points improves frequency resolution at the expense of update speed. The point choices available are dependant on the data being operated upon.

Horizontal Magnify Mode This mode allows you to specify the frequency that is displayed at center screen, and magnify the frequency-domain display about that point. Magnification increases as the number of time-record samples increases. At the maximum of 32,768 points, magnification reduces the displayed frequency span to about 12% of that in the unmagnified display. Horizontal magnification allows you to zero in on and expand desired portions of the frequency-domain display.

Center Frequency Control Enabling horizontal magnification allows you to set the center of the display to a frequency of interest. The display is magnified about that point so that you get a closer view.

Selectable Windows Three windows are selectable: Hanning, for best frequency resolution and general purpose use; flattop, for best amplitude accuracy; and rectangular, for single-shot signals such as transients and signals where there are an integral number of cycles in the time record.

Maximum Displayed Frequency 5 Hz to 1 GHz selectable (real-time acquisition). Display is from dc to a selectable upper frequency, in steps from 5 Hz to 1GHz. Maximum frequency displayed is 1/2 the sample rate.

Window Characteristics The window characteristics are shown below.

Window	Highest Side Lobe (dB)	3 dB Bandwidth (bins)	6 dB Bandwidth (bins)	Scallop Loss (dB)
Rectangular	–13	0.89	1.21	3.92
Hanning	–32	1.44	2.00	1.42
Flattop	–70	3.38	4.17	0.005

Highest Side Lobe The minimum attenuation in the stop band. It indicates the level of leakage present in the filter; that is, how high the skirts are in relation to the main peak.

3 dB bandwidth The width of the peak at a level 3 dB down. A narrow 3-dB bandwidth helps in separating frequency peaks that are close together.

6 dB Bandwidth The width of the peak at a level 6 dB down.

Bins The distance between frequency points. One bin equals the resolution.

Scallop Loss The attenuation of the peak half way between bins. The scallop loss determines the amplitude accuracy of a window. It measures the attenuation of a signal that falls between frequency bins versus one that is exactly on a frequency bin.

Split display operation A time-domain waveform and its FFT spectrum can be displayed simultaneously on the top and bottom halves of the screen. Four FFT spectra can be displayed simultaneously in the same way. Four sets of time-domain waveforms and their spectra may also be displayed simultaneously.

Log Display Sensitivity and offset can be set by the user.

Waveform Save

The oscilloscope contains four nonvolatile waveform memories, two volatile pixel memories, and 665 multiple failure memories. The four nonvolitile memories can store four waveforms up to 32K each. The 665 multiple failure memories store 500-point records. Waveform memories store single-valued waveforms, such as an averaged waveform. If an envelope waveform is stored to a waveform memory, it is automatically stored with the upper waveform in one waveform memory and the lower waveform in another. You can perform automatic measurements on the four nonvolatile waveform memories but not the volatile pixel memories.

Waveform memory pairs m1/m2 and m3/m4 also store the upper and lower limit masks used during compare testing. You can create and edit these masks using sample signals, or you can create them manually.

Pixel memories store an entire screen of waveform data. Use them for storing multiple overlapping waveforms and infinite persistence waveforms.

Multiple memories store failure data from limit and compare tests. You can view or transfer this data to the waveform memory for nonvolatile storage or measurement.

Waveform and pixel memories can be saved to the disk drive (Disk menu).

Automatic Pulse Parameter Measurements

The oscilloscope offers 23 automatic pulse parameter measurements from the front panel (shown below) and over HP-IB. The standard measurements are performed with 10%, 50%, and 90% voltage thresholds, as defined by IEEE standard 194-1977, "IEEE Standard Pulse Terms and Definitions."

Automatic measurements available on the oscilloscopes

Rise	Fall	Frequency	Period	preshoot	time at max voltage
+width	–width	Duty cycle	Δ Time	overshoot	time at min voltage
V p-p	V min	V max	V avg	voltage at time	time at voltage
V amptd	V base	V top	V ac rms		
			V dc rms		

User-definable Measurement Thresholds The oscilloscope allows you to set your own thresholds for automatic measurements. You can set both the upper and lower thresholds from –25% to 125%, as long as the upper threshold value is always greater than or equal to the lower threshold. The middle threshold is always equal to the midvalue between the upper and lower threshold.

Continuous Measurements You can turn continuous measurements on or off. With continuous measurements off, the voltage (y) and time (x) markers are placed on the waveform to indicate where the last measurement was taken.

Measurement Statistics The maximum, minimum, average, standard deviation, and most recent of continuously updated measurements are calculated and displayed. You can select any three measurements for simultaneous display.

Measurement Limit Test You can set the maximum and minimum limits for any three of the front-panel automatic measurements. These continuously updated measurements are compared to the maximum and minimum limits. If the measurements are outside the defined limits, you can store the waveform in a memory or print the screen on a hardcopy device. In addition, the HP-IB Service Request line can be set to flag the controller. You can set the measurement limit test to stop after test limits are exceeded, or to continue testing.

Setup Aids

Autoscale Pressing the Autoscale button automatically adjusts the vertical, horizontal, and trigger to best display the input signals. Autoscale requires a signal with a duty cycle greater than 0.5% and a frequency greater than 50 Hz. Autoscale is effective only for relatively stable input signals.

Undo autoscale Undo autoscale returns the instrument to the setup previous to the autoscale. (See Recall 0.)

Save/Recall You can save nine front panel setups (1 to 9) in nonvolatile memory.

Recall Clear Pressing the Recall key followed by the Clr key resets the oscilloscope to its default settings.

Recall 0 If Autoscale, ECL or TTL preset, or recall setup are inadvertently selected, recall 0 restores the instrument to the previous setup.

Show Displays instrument status, including volts/div, offset, and trigger condition.

Disk Drive

There is a high density, 3.5-inch, MS-DOS® compatible disk drive on the front panel.

MS-DOS® is a US registered trademark of the Microsoft Corporation.

Hardcopy

You can transfer the CRT display, including menus and measurement answers, directly to a wide variety of HP graphics printers and plotters.

Full HP-IB Programmability

The oscilloscope is fully programmable. Instrument settings and operating modes, including automatic measurements, are remotely programmed over HP-IB (IEEE-488). HP-IB programming complies with IEEE 488.2-1988 "Standard Codes, Formats, Protocols, and Common Commands."

Sequential Single-shot Data Acquisition and Transfer Rate Using the front- panel time base menu or HP-IB command "Raw Data," the oscilloscope can automatically capture, store, and label a waveform; and rearm the trigger; and then repeat this process until the oscilloscope's entire 400K word RAM (volatile) is filled. Once the specified number of waveforms are captured and stored, the oscilloscope can transfer the entire block of waveforms to the external computer. HP-IB bus users can specify the number of points to store and the number of waveforms to capture. Repetition rates vary depending on record length and time base setting (slower sampling rates).

Data Transfer Rate Approximately 120 Kbytes per second.

CAL Signals

Probe Compensation, ac Calibrator Output A square wave signal is provided on the front panel and rear panel for probe compensation and other uses. The default frequency is approximately 500 Hz, but it is adjustable from approximately 250 mHz to about 32 kHz. During instrument self-calibration, this output is used to provide other calibration signals, as described in the Service Guide.

The rear panel BNC connector is also used for trigger output. From the utility menu you can switch the BNC from probe compensation and calibration signals to a trigger output pulse. The rising edge, with amplitude from about –400 mV to 0 V (when terminated into 50 Ω), is synchronous with system trigger. The falling edge of this pulse is approximately at the start of the acquisition. The rising edge should be used as the edge synchronous with trigger.

dc Calibrator Output This output is used for vertical calibration of the oscilloscope, as described in the Service Guide.

Product Support

Built in Self-Test and Calibration Routines Internal self-test capabilities provide a 90% confidence the oscilloscope is operating properly. External test procedures in the Service Guide provide a 100% confidence. Self-calibration routines, also selected through the front-panel "utility" menu, ensure that the instrument is operating with its greatest accuracy and require no external test equipment.

Low Cost of Ownership The oscilloscope includes a standard three year, return to HP warranty.

To minimize the repair and calibration times, the oscilloscope was designed with only one main assembly adjustment per channel. In addition, Hewlett-Packard's board exchange program assures economical and timely repair of units, reducing the cost of ownership.

Reliability Estimated mean time between failures (MTBF) for this oscilloscope is 30,000 hours. MTBF is computed using an instrument usage of 2,000 hours per year.

Solutions Hewlett-Packard's System Engineering Organization can help you configure an HP-IB system and provide software support for your application, developing solutions to meet your measurement needs. Contact your HP Sales Office for more information.

General Characteristics

These general characteristics apply to these oscilloscopes.

Environmental Conditions

The instruments meet Hewlett-Packard's environmental specifications (section 750) for class B-1 products with exceptions as described for temperature and condensation. Contact your local HP field engineer for complete details.

Temperature

Operating 0 °C to +55 °C (32 °F to +131 °F)
Nonoperating –40 °C to +70 °C (–40 °F to +158 °F)

Humidity

Operating up to 95% relative humidity (non-condensing) at +40 °C (+104 °F)
Nonoperating up to 90% relative humidity at +65 °C (+149 °F)

Altitude

Operating up to 4,600 meters (15,000 ft)
Nonoperating up to 15,300 meters (50,000 ft)

Vibration

Operating Random vibration 5 to 500 Hz, 10 minutes per axis, 0.3 grms
Nonoperating Random vibration 5 to 500 Hz, 10 minute per axis, 2.41 grms; Resonant search, 5 to 500 Hz swept sine, 1 Octave/minute sweep rate, 0.75g, 5 minute resonant dwell at 4 resonances per axis.

Power Requirements

Voltage 115/230 Vac, –25% to +15%, 48 to 440 Hz.

Power 350 VA maximum

Weight

Net Approximately 11.8 kg (26 lb)

Shipping Approximately 21.3 kg (47 lb)

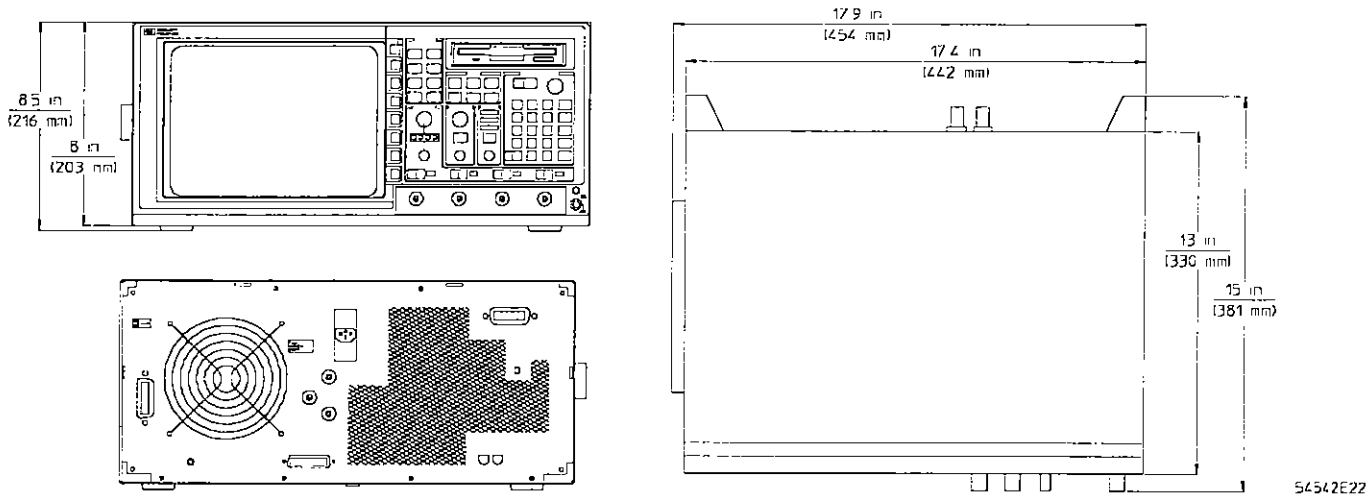
Dimensions

Refer to the outline drawings on the next page.

Notes

1 Dimensions are for general information only. If dimensions are required for building special enclosures, contact your HP field engineer.

2 Dimensions are in inches and (millimeters).



Product Regulations

Safety

IEC 348
UL 1244
CSA Standard C22.2 No.231 (Series M-89)

EMC

This product meets the requirement of the European Communities (EC) EMC Directive 89/336/EEC.

Emissions

EN55011/CISPR 11 (ISM, Group 1, Class A equipment)
SABS RAA Act No. 24 (1990)

Immunity

EN50082-1	Code[1]	Notes[2]
IEC 801-2 (ESD) 4 kV CD, 8 kV AD	2	
IEC 801-3 (Rad.) 3 V/m	2	
IEC 801-4 (EFT) 1 kV	2	

[1] Performance Codes:
1 PASS—Normal operation, no effect.
2 PASS—Temporary degradation, self recoverable.
3 PASS—Temporary degradation, operator intervention required.
4 FAIL—Not recoverable, component damage.

[2] Notes:
(None)

Recommended Test Equipment

The following table is a list of the test equipment required to test performance, calibrate and adjust, and troubleshoot this instrument. The table indicates the critical specification of the test equipment and for which procedure the equipment is necessary. Equipment other than the recommended model may be used if it satisfies the critical specification listed in the table.

Recommended Test Equipment

Equipment Required	Critical Specifications	Recommended Model	Use *
Signal Generator	1 - 500 MHz, sine wave, amplitude 30 - 200 mVrms, time base accuracy 0.25 ppm	HP 8656B, Opt 001	P
Pulse Generator	tr = 1.0 to 2.8 ns, 280 mVp-p, externally triggerable	HP 8161A	P
Power Meter/Power Sensor	1 - 500 MHz, -70 dBm to +44 dBm, ±3% accuracy	HP 436A/HP 8482A	P
DMM	6 1/2 digit (0.1 mV) resolution, dcV accuracy 8 ppm/year, 4-wire resistance acc. ±0.25%	HP 34401A	P, A, T
Power Supply	7 mV - 30 V dc, 0.1 mV accuracy and resolution	HP 6114A	P
Pulse Generator	tr <175 ps	Picosecond Pulse Labs 1110B Driver, 1107B Head	A
Power Splitter	50 Ω type N, outputs differ by <0.15 dB	HP 11667A	P
Oscilloscope	General-purpose	HP 54501A	P, T
Blocking Capacitor	0.18 µF	HP 10240B	P
Cable	Type N (m)(m) - 3 foot	HP 11500A or B	P
Cable (2)	BNC - 3 foot	HP 10503A	P, A, T
Cable (3)	BNC - 9 inch	HP 10502A	P, A, T
Adapter	N (m) to BNC (m)	HP 1250-0082	P
Adapter	N (m) to BNC (f)	HP 1250-0780	P
Adapter	N (f) to BNC (m)	HP 1250-0077	A
Adapter	SMA (m) to BNC (m)	HP 1250-1787	A
Adapter (2)	BNC tee (m)(f)(f)	HP 1250-0781	P, T
Adapter	BNC (f)(f)	HP 1250-0080	T
Adapter (2)	BNC (f) to dual banana (m)	HP 1251-2277	P
Shorting cap	BNC	HP 1250-0774	P
Cable Extender	no substitute	HP 54542-61609	A, T
Resistor	2 Ω, 25 W	HP 0811-1390	T

*. P = Performance Tests, A = Adjustments, T = Troubleshooting

2

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Preparing for Use

Preparing for Use

This chapter shows you how to prepare the HP 54520 and 54540 series oscilloscopes for use. The following areas are covered in this section.

- Inspection
- Setup
- Cleaning

Following instrument setup is a brief section covering oscilloscope operation. This section is derived from the quick start guide for these oscilloscopes. If you are unfamiliar with this oscilloscope's operation and do not have the User's Guides, this section will help you. The topics covered include:

- Connecting a signal
- Making voltage and timing measurements
- Storing and retreiving data
- Printing hard copy

Setting Up the Oscilloscope

This section will help you get the instrument ready to use. Included here are procedures for:

- Inspection
- Checking and setting power requirements
- Cleaning

To inspect the instrument

☐ Inspect the shipping container for damage.

Keep a damaged shipping container or cushioning material until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically.

☐ Check the accessories.

Accessories supplied are listed in chapter 1 of this service guide.

- If the contents are incomplete or damaged notify your HP sales office.

☐ Inspect the instrument.

- If there is mechanical damage or defect, or if the instrument does not operate properly or pass performance tests, notify your HP sales office.
- If the shipping container is damaged, or the cushioning materials show signs of stress, notify the carrier as well as your HP sales office. Keep the shipping materials for the carrier's inspection. The HP office will arrange for repair or replacement at Hewlett-Packard's option without waiting for claim settlement.

To check power requirements

The instrument requires a power source of 115 Vac or 230 Vac, –22% to +15%, 48 to 440 Hz, 350 VA maximum.

CAUTION

BEFORE CONNECTING POWER TO THIS INSTRUMENT, be sure the line voltage switch on the rear panel of the instrument is set properly. Applying a voltage excessive to the setting may open the protective fuse.

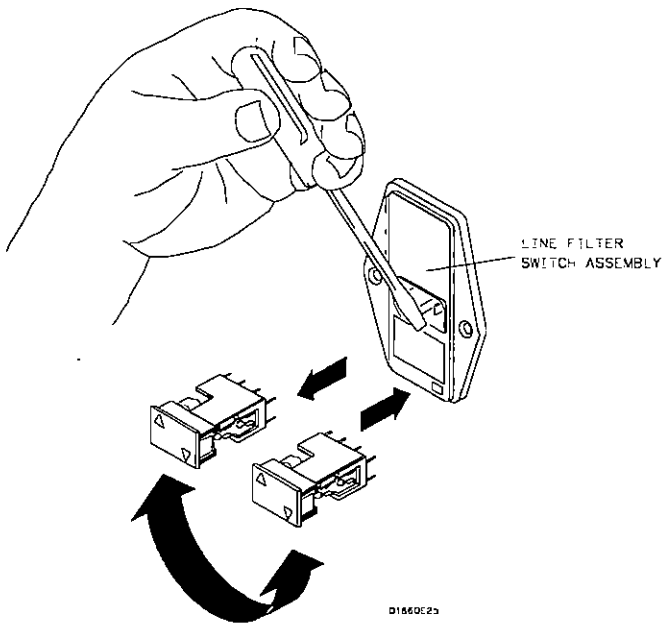
To set the line voltage selection

Before applying power, verify the line voltage selection set on the line filter module on the rear panel. When shipped from HP, the line voltage selector is set to operate the instrument in the country of destination. If you need to operate the instrument from a different power source, use the following procedure to change the setting.

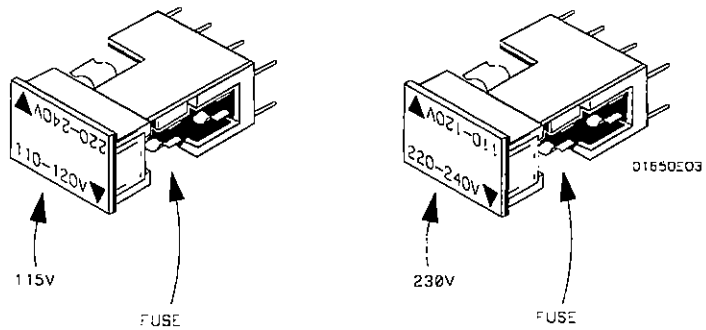
1 Remove the power cord from the instrument.

2 Remove the fuse module.

Use a small flat-blade screwdriver to carefully pry at the slot next to the power cord connector until you can remove the fuse module with your hand.



3 Use the following figure to check the fuse.



For information about the fuse, see the parts list in chapter 7, "Replaceable Parts."

4 Reinsert the fuse module with the mark for the appropriate line voltage aligned with the the mark on the line filter module.

5 Reconnect the power cord.

WARNING

SHOCK HAZARD!
BEFORE YOU CONNECT THIS INSTRUMENT TO MAINS POWER OR LIVE MEASURING CIRCUITS, you must provide a protective earth ground. Failure to provide a protective earth ground could result in a shock hazard if there is a failure in this instrument or equipment connected to it.
The mains plug must be inserted in a socket outlet provided with a protective earth contact. Do not use an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet does not provide an instrument ground.

This instrument is provided with a three-wire power cable. When connected to an appropriate ac power outlet, this cable grounds the instrument cabinet. The type of power cable plug shipped with the instrument depends on the country of destination.

To clean the instrument

To clean the instrument, use a soft cloth, damp with a mild soap and water solution.

Following is a quick introduction to the oscilloscope. It is not intended as a comprehensive guide, but rather as help for people who need only a brief overview.

Important features of the front panel

The front panel contains seven keypad areas and one set of softkeys. The figure on the facing page shows the location of each of these areas, and the text below describes the functions of the keys found in each area.

Some keys have two functions, one regular function and one shifted function. The shifted function is the one printed in blue just above the key. To use a shifted function, first press the blue key, indicated by `(blue)` in this book.

1 Entry/Measure area (Keypad)

The keys in this area have two functions. First, the numeric keys let you enter values in menu areas that you have highlighted with softkey presses. These values might be for voltages, vertical position, or other numerical data. The second function is the shifted function of each key, measurements like Vp-p, Period, V avg, and Frequency written in blue above the key. The `(blue)` key is also located in this area.

2 Menu area

The keys in this area select menus that appear in the softkey part of the display.

3 Control area

The keys in this area let you control the acquisition of signals and printing.

4 Softkey and menu area

The keys in this area are defined by the labels printed next to them on the display. These labels change depending on the menu previously selected.

5 Setup area

The keys in this area let you save oscilloscope settings to one of nine memory locations and recall them later.

6 Vertical area

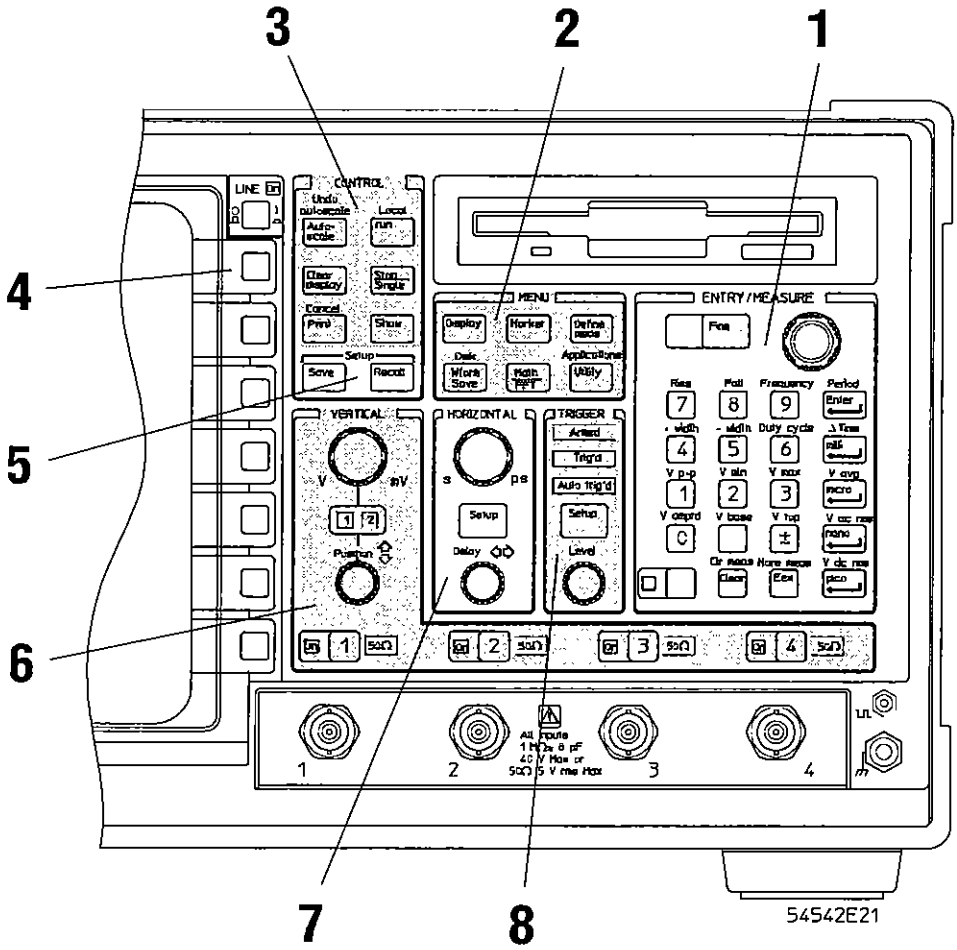
The controls in this area let you make V/div and position adjustments, and select channel menus for further vertical and probe control.

7 Horizontal area

The controls in this area let you make s/div and delay adjustments, and access the Horizontal menu.

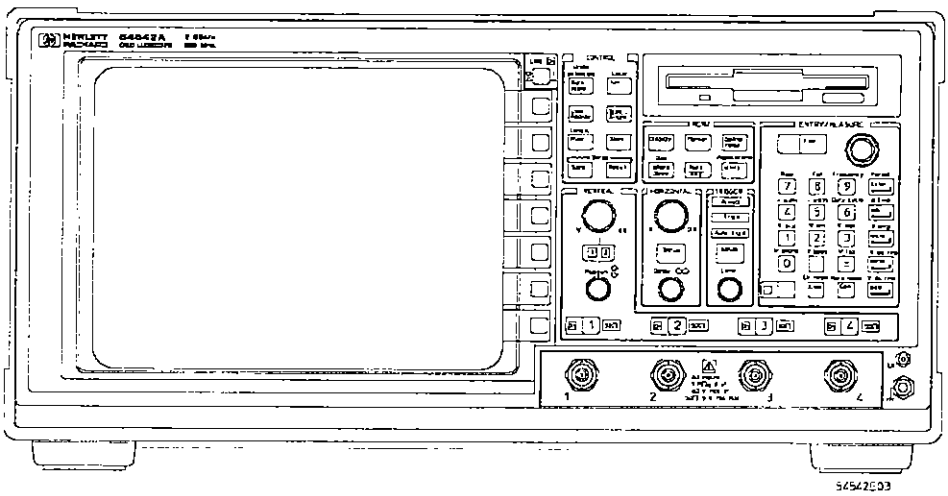
8 Trigger area

The controls in this area let you establish the trigger conditions for data acquisition.


3
2
1
4
5
6
7
8
CONTROL
MENU
ENTRY/MEASURE
VERTICAL
HORIZONTAL
TRIGGER
54542E21

To connect a signal

- Connect the supplied probe between the probe comp on the front panel and the channel 1 input at the bottom of the front panel.



To set the instrument to a known starting condition

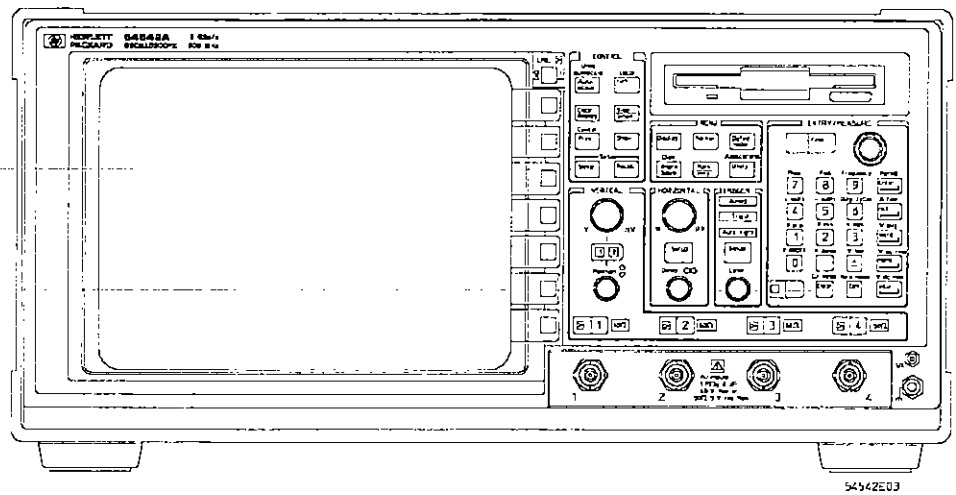
Other users may set up the instrument in a way that will invalidate or obscure measurements you want to make. Each time you use the oscilloscope, you should set it to a starting condition that will allow you to avoid those problems.

The easiest way to do this is with the following procedure:

1 Press the `Recall` key in the Setup area.

2 Press the `Clr` key in the Entry/Measure area.

If you want more information on instrument setup conditions, please see the *HP 54520 and 54540 Series Oscilloscope User's Reference*.



To measure peak-to-peak voltage

1 Press Autoscale.

2 Press the `(blue)` key on the Entry/Measure keypad.

3 Press the `Vp-p` key on the Entry/Measure keypad.

Notice the message at the top of the display that tells how use the knob to select function, channel, or memory. The instrument also prompts you for a channel number at the bottom of the display.

4 Press the `1` key on the Entry/Measure keypad to select channel number 1.

Notice that Vp-p is shown at the bottom of the display area.

To measure a waveform period

1 Press the (blue) key on the Entry/Measure keypad.

2 Press the Period key on the Entry/Measure keypad.

3 Press the 1 key on the Entry/Measure keypad to select channel number 1.

Notice that Period is shown at the bottom of the display area.

To set the probe attenuation

If you are using a 10 to 1 probe, you may have noticed that the voltage readings you've gotten are off by a factor of 10. That is because the probe attenuation factor has not yet been set. To set probe attenuation, use the following procedure.

1 Press the channel 1 key at the bottom of the vertical area to bring up the Vertical menu.

2 Press the **more/preset probe** softkey at the bottom of the menu.

Note that the probe attenuation field is highlighted and reads 1.000 : 1.

3 Use the knob or numerical keys in the Entry/Measure area to set probe attenuation to 10.00 : 1.

Notice that as you change the attentuation factor, the voltage measurements at the bottom of the display change scale also.

To change vertical scale

1 Press the Show key in the Control area to see the state of the instrument.

2 Turn the V/div knob, the large knob in the Vertical area of the front panel, and notice that the signal's amplitude varies.

Normally, the V/div settings vary in a 1,2,5 sequence. For vernier control of V/div scale, press the Fine key and then move the V/div knob. Note the lighted indicator next to the key when the Fine function is in effect.

3 Turn the small knob, labeled Position (offset), and watch the effect on the signal.

Note the channel numbers between the knobs in the Vertical area. The number that is lit represents the active channel and that channel is affected by changes made with the knobs. Also, there are indicators next to each channel key at the bottom of the Vertical area. When a channel is on, its indicator will be lit.

To change horizontal scale

1 Turn the large knob in the Horizontal area of the front panel and notice the changes to the signal and to the s/div setting under the graticule.
2 Turn the small knob, labeled Delay, and notice that the signal moves left or right on the display.

To modify the edge trigger level

1 Press the `Setup` key in the Trigger area of the front panel. Notice the Edge Trigger menu on the display.
2 Turn the Level knob in the Trigger area of the front panel and notice that the trigger level value changes in the menu area and the trigger cursor moves to indicate the new level.

To pan and zoom on a signal

1 Press `Recall` , `Clear` , and `Autoscale` .

This will return the instrument to a known starting condition and provide a scaled signal.

2 Press the `Setup` key in the Horizontal area to bring up the menu.

3 Press the **`record length`** softkey near the bottom of the menu.

Notice that the value is now highlighted.

4 Turn the large knob in the Entry/Measure area to set the record length to 4096.

The reason for doing this now is to provide a longer signal record length to view for this exercise. You can select any value between 512 and 32K, but 4096 will provide a record length adequate to show how to pan and zoom.

5 Press the `Stop/Single` key to stop signal acquisition.

6 Turn the large knob in the Horizontal area to zoom in and out on the signal.
7 Turn the small knob in the Horizontal area to pan along the signal

If you look at the top of the display, you will see a bar called the memory bar. In the real-time mode, the entire length of the memory bar represents the data record the instrument has captured. The bolded part of the bar represents the part of the data record that is displayed on the instrument. The indicator on the memory bar represents the trigger point. Note the actions on the memory bar as you pan and zoom on the signal.

To use softkey menu items

The fields in the softkey menu areas are of three basic types. To see how they work, press the Channel 1 key at the bottom of the Vertical area and press softkeys to see the effect. Then, press the Setup key in the Horizontal area and do the same. The three softkey types are:

- Toggle, in which you toggle between two states each time the softkey is pushed. The two states might be On and Off, for example.
- One in which several selections are available, and each time the softkey is pushed a new selection is made. The selections are made in a left to right and top to bottom sequence. The active selection is highlighted.
- One in which a value is either highlighted or dimmed. To highlight a value, press the softkey next to it. Then, the highlighted value may be changed with either the knob or the numeric keys in the Entry/Measure area.

  You may change some values even though they are not highlighted by using the knobs in the Vertical and Horizontal areas. When these values are highlighted, you may also change them using the knob and numeric keys in the Entry/Measure area.

To save a setup to memory

1 Press the `Save` key in the Setup area.

2 Press a key between 1 and 9 on the Entry/Measure keypad to select the memory location for the setup.

You can store nine setups in the oscilloscope's internal nonvolatile memory.

To recall a setup from memory

1 Press the `Recall` key in the Setup area.

2 Press the key on the Entry/Measure keypad corresponding to the memory location of the setup you want to recall.

The previous setup is always stored in memory location 0. If you want to return to the previous setup, press the Recall key and the 0 key.

If you have many setups that you use and want them available to load quickly, you may also store them to disk. See the *HP 54520 and 54540 Series Oscilloscopes User's Reference* for storing setups to disk.

To save a waveform to disk

1 Put a formatted disk into the instrument's disk drive.

For information of formatting disks, see the HP54520 and 54540 Series Oscilloscope User's Reference.

2 Press the `(blue)` key and then the `Disk` key in the menu area.

3 Press the **store** softkey in the DISK menu.

4 Select **wav** from the STORE menu.

5 Select **internal**.

6 Select the data source in the **data from** field.

7 Press the **to file** softkey.

a Use the knob in the keypad area to select letters for the filename.

b Press the top softkey to enter each letter selected.

c Press the **done** softkey when the filename is complete.

8 This action will clear any softkey menu from the display, allowing you to see the setup information. Press the **execute** softkey.

To load a waveform from disk

1 Press the `(blue)` key and then `Disk` on the Menu keypad.

2 Press the **load** softkey to bring up the LOAD menu.

3 Select the proper parameters from the menu including the name of the file to load and its destination.

4 Press the **execute** softkey to bring the file into memory and **exit menu** to return to the DISK menu.

5 Press the **Wform Save** key in the Menu area.

6 Select **waveform** and memory location in the **nonvolatile** field from the menu.

7 Turn display **on**.

Waveforms already on the display may obscure the one you've just loaded. Either turn those waveforms off using the Vertical menu, or use the V/div and Position knobs to separate the waveforms.

If you want to see the setup parameters for the waveforms you are presently viewing, press the Show key in the Control area.

> You can also save four waveforms to nonvolatile memory. For information about how to store waveforms to memory, see the *HP 54520 and 54540 Series Oscilloscope User's Reference.*

To print a hardcopy

1 Press the `Utility` key.

2 Press the **`HPIB/RS232`** menu softkey.

3 Select **`HPIB Talk`**.

The proper HP-IB setup for the printer and port must be in place to print. Refer to the *HP 54520 and 54540 Series Oscilloscope User's Reference*.

4 Press the `Print` key.

To cancel a print request, press the `(blue)` key, and press the `Cancel` key on the Control keypad.

3

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Testing Performance

Testing Performance

The procedures in this section test the instrument's electrical performance using Performance Specifications given in chapter 1 as performance standards. Specifications applicable to individual tests are noted at the test for reference.

Testing Interval

The performance test procedures may be performed for incoming inspection of the instrument and should be performed periodically thereafter to ensure and maintain peak performance. The recommended test interval is yearly or every 2,000 hours of operation. Amount of use, environmental conditions, and the user's experience concerning need for testing will contribute to test requirements.

See Also Chapter 4, "Calibrating and Adjusting," for information about the calibration cycle.

Equipment Required

A complete list of equipment required for the performance tests is in the Recommended Test Equipment table in chapter 1. Equipment required for individual tests is listed in the test. Any equipment satisfying the critical specifications listed may be substituted for the recommended model. The procedures are based on the model or part number recommended.

Self-Test Verification

To verify system operation with high confidence, without the test equipment and time required for performance tests, perform the self-tests. These internal tests verify many functions on the main assembly. The functions tested are the six separate memories and six other system functions.

To start the self-tests, press `Utility` , then press **`selftest menu`**. A message is displayed with the instruction to remove all inputs to the instrument. Press **`test all`**, which starts a loop which runs all the self-tests in succession. During execution of the self-tests, the following messages are displayed as each self-test is completed:

PASSED	Display RAM	PASSED	Acquisition RAM
PASSED	System RAM	PASSED	Logic Trigger
PASSED	Non-Volatile RAM	PASSED	Analog Trigger
PASSED	Protected Non-Volatile RAM	PASSED	Timebase
PASSED	System ROM	PASSED	Time Tag
PASSED	HP-IB	PASSED	D/A Converter
		PASSED	A/D Converter

If one of the self-tests fails, **`FAILED`** is displayed rather than **`PASSED`**, and a 16-bit diagnostic code is displayed. This code is used by factory service personnel when troubleshooting the main assembly. Failure of a self-test indicates a failure on the main assembly which must be returned to the factory for service. For more troubleshooting information, refer to chapter 5, "Troubleshooting."

The **loop** test in the **selftest menu** is a troubleshooting aid for factory service only.

Test Record

You may record the results of the performance tests in the Performance Test Record provided at the end of this chapter. The Performance Test Record lists the performance tests and provides an area to mark test results. You can use the results recorded at incoming inspection for later comparisons during periodic maintenance, troubleshooting, and after repairs or adjustments.

Operating Hints

Some knowledge of operating the oscilloscope is helpful; however, these procedures are written so that little experience is necessary. The following two hints will speed progress of the testing.

Clear Display

When using many averages, it often takes awhile for a waveform display to stabilize after a change. When a control on the oscilloscope is changed, averaging automatically restarts. When just the input signal is changed, the instrument must average new data with the old so it takes longer for the waveform to stabilize. Press `Clear display` while changing input signals. The instrument will restart averaging and give a quick indication of the result of the signal change.

Averaging

Averaging is used to assure a stable signal for measurements. It is not necessary to wait for complete stability of the signal (averaging complete), as long as the measurement is well within the limits of the test.

Keystroke Conventions

To guide you while setting up the oscilloscope the following conventions are used to represent keystrokes and other interactions with the instrument:

Text in a box, such as `Utility` or `Time base` , represents hardkeys, those defined by text on the front panel.

Bold text in a typewriter font, such as **`Display`** or **`Calibrate...`**, represents text on the CRT screen and may be a softkey you should press or a message to consider.

The blue key that has no writing on it is a shift key. It allows you to access the functions written in blue above some of the hardkeys. In this guide it is represented by a box with the word "blue" in it, like this: `(blue)` .

Specifications

The specifications that apply to a particular test are given at the test. The specification as given at the test may be abbreviated for clarity. In case of any questions, refer to the complete specifications and characteristics in chapter 1, "General Information."

Performance Test Procedures

Performance test procedures start with the next paragraph. Procedures may be done individually and in any order.

CAUTION

Allow the instrument to warm up for at least 30 minutes prior to beginning performance tests. Failure to allow warm-up may cause the instrument to fail tests.

To test the dc Calibrator

The DC CALIBRATOR output on the rear panel is used for self-calibration and probe calibration. Though calibrator accuracy is not specified in the performance specifications, it must be within limits in order to provide accurate self-calibration.

Test Limits 5.000 V ±10 mV

Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Digital Multimeter	0.1 mV resolution, better than 0.1 % accuracy	HP 34401A
Cable	BNC	HP 10503A
Adapter	BNC (f) to banana (m)	HP 1251-2277

Procedure

1 Connect the multimeter to the rear panel DC CALIBRATOR output.

2 Press `Utility` then `service menu`, then press `cal select` to select `cal select 1` (1. DC CAL BNC verify)

3 Press `dac output` to select `0 volt`. The DVM should read close to 0.0000 V.

4 Record the reading to four decimal places. V1 = _____.

5 Press `dac output` to select `5 volt`. The DVM should read near 5.000 V. V2 = _____.

6 Subtract V1 from V2. The difference should be between 4.990 and 5.010 V.

7 Record the results of step 6 in the Performance Test Record.

8 Press `exit menu`.

If the test fails
Repair is necessary. See chapter 5, "Troubleshooting."

To test input resistance

This test checks the input resistance of the vertical inputs. A four-wire measurement is used for accuracy at 50 Ω.

Specification 1 MΩ ±1% and 50 Ω ±1%

Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Digital Multimeter	Measure resistance (4-wire) better than 0.25% accuracy	HP 34401A
Cables (2)	BNC	HP 10503A
Adapter	BNC Tee (m)(f)(f)	HP 1250-0781
Adapters (2)	BNC (f) to dual banana (m)	HP 1251-2277

Procedure

1 Set up the multimeter to make a four-wire resistance measurement.

2 Assemble the test cables

- **a** Use the BNC-to-banana adapters to connect one end of each BNC cable to the four-wire resistance connections on the multimeter.
- **b** Connect the free ends of the cables to the BNC tee.

3 Connect the male end of the BNC tee to the channel 1 input of the oscilloscope.

4 Press the appropriate channel number key (bottom row) to select the channel menu.

5 Use the impedance softkey (second from bottom) to select `1 MΩ`, then `50Ω DC`, and verify resistance readings of 1 MΩ ±10 kΩ and 50 Ω ±0.5 Ω respectively.

6 Record the readings in the Performance Test Record.

7 Repeat steps 3 through 6 on the remaining channels and the Ext trigger of the HP 54520A and 54522A.

To test voltage measurement accuracy

This test verifies the voltage measurement accuracy of the instrument. The measurement is made in a way that offset errors are not a factor.

Specification

Dual Cursor ±(1.25% of full scale + 0.032 × V/div)

Single Cursor ±[1.25% of full scale + offset accuracy + (0.016 × V/div)]

Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Power Supply	7 mV to 30 Vdc, 0.1 mV resolution	HP 6114A
Digital Multimeter	Better than 0.1% accuracy	HP 34401A
Cables (2)	BNC	HP 10503A
Adapters (2)	BNC (f) to banana (m)	HP 1251-2277
Adapters (2)	BNC tee (m)(f)(f)	HP 1250-0781
Blocking capacitor	0.18 µF	HP 10240B
Shorting cap	BNC	HP 1250-0774

Procedure

A power supply provides a reference voltage to check measurement accuracy. The supply is monitored for accuracy (especially at low voltages). A dc blocking capacitor is used to filter noise on the input voltage to the oscilloscope.

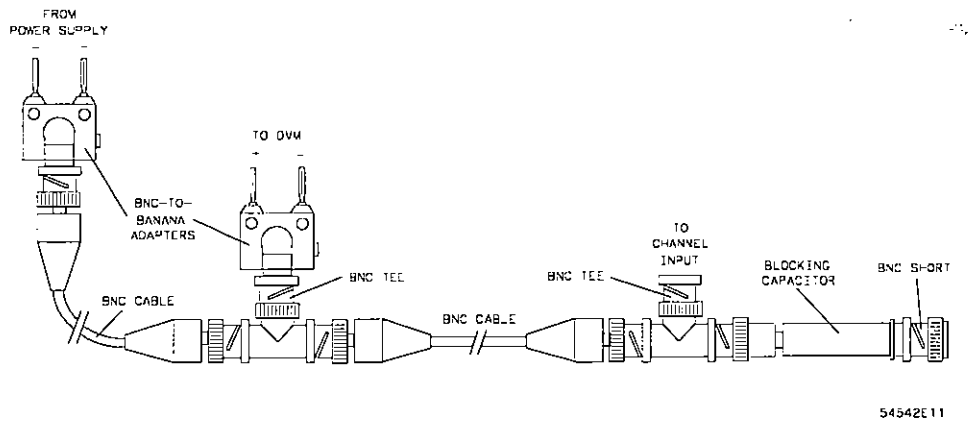
1 Connect the equipment.

a Use a BNC-to-banana adapter to connect a BNC cable to the power supply.

b Connect a BNC tee to the other end of the cable and use a BNC-to-banana adapter to connect the tee to the DVM

c Connect another BNC cable to the tee at the DVM and connect a BNC tee to the cable.

d Connect the blocking capacitor to the BNC tee and connect the BNC shorting cap to the blocking capacitor.



Voltage Measurement Accuracy Equipment Setup

2 Press Recall, then press Clr to set the oscilloscope to default conditions. Set the following parameters.

Menu (hardkey)	Function/Parameter	Setting
Horizontal	Setup	repetitive
Display	(mode)	average
	# of avg	32

3 Use the following table for steps 4 through 9.

Volts/div	Position	Supply	Tolerance	Limits	
				minimum	maximum
5 V	15 V	30 V	±0.66 V	29.34 V	30.66 V
5 V	15 V	15 V	±0.66 V	14.34 V	15.66 V
5 V	15 V	5 V	±0.66 V	4.34 V	5.66 V
200 mV	600 mV	1.2 V	±26.4 mV	1.1736 mV	1.2264 mV
200 mV	600 mV	600 mV	±26.4 mV	573.6 mV	626.4 mV
200 mV	600 mV	200 mV	±26.4 mV	173.6 mV	226.4 mV
10 mV	30 mV	60 mV	±1.32 mV	58.68 mV	61.32 mV
10 mV	30 mV	30 mV	±1.32 mV	28.68 mV	31.32 mV
10 mV	30 mV	10 mV	±1.32 mV	8.68 mV	11.32 mV
7 mV	21 mV	42 mV	±0.924 mV	41.076 mV	42.924 mV
7 mV	21 mV	21 mV	±0.924 mV	20.076 mV	21.924 mV
7 mV	21 mV	7 mV	±0.924 mV	6.076 mV	7.924 mV

Below 7 mV/div expansion is used and full scale is defined as 56 mV. The ranges from 1 to 6 mV/div are accomplished in firmware, and will be within specifications when the 7 mV/div range is within specifications.

4 Initiate a V avg measurement.

Press (blue), V avg, and 1 (channel number, entry menu).

5 Press the channel number key (bottom row) and set the V/div range and position from the first line of the table.

6 With the supply disconnected from the channel input, note the V avg reading.

_____ mV

7 Set the power supply voltage from the first line of the table.

8 Connect the power supply to the channel input and note the V avg reading.

_____ V

9 Subtract the value in step 6 from the value in step 8. Record the difference in the Performance Test Record.

10 On the same channel, Repeat steps 5 through 9 for the rest of the lines of the table.

11 With the channel keys (bottom row), set the active channel off and the next on.

12 Move the blocking capacitor combination to the next channel and repeat steps 4 through 11 for that channel.

13 Repeat steps 5 through 12 for the rest of the channels.

If the test fails

Voltage measurement errors can be caused by the need for self-calibration. Before troubleshooting the instrument, perform self-calibration, **0. vertical cal**, (see "To Calibrate the Firmware" in chapter 4, "Calibrating and Adjusting"). If self-calibration fails to correct the problem, the cause may be the attenuator or main assembly.

To test offset accuracy

This test checks the offset accuracy.

Specification ±(1.25% of channel offset + 2% of full scale)

Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Power Supply	0.5 V to 2 Vdc, ±1 mV accuracy	HP 6114A
Cable	BNC	HP 10503A
Adapter	BNC (f) to dual banana (m)	HP 1251-2277

Procedure

1 Press `Recall` then `Clr` to set the oscilloscope to default conditions, then set the following parameters.

Menu (hardkey)	Function/Parameter	Setting
Horizontal	Setup	repetitive
Display	(mode)	avg
	# of avg	32
Entry	Fine	(on)

2 Use the banana-to-BNC adapter to connect the BNC cable between the power supply and channel 1 input.

3 Use the following table for steps 4 through 7.

Volts/div	Position	Supply	Tolerance	Limits minimum	Limits maximum
200 mV	2.00000 V	2.00 V	±57 mV	1.943	2.057 V
100 mV	1.00000 V	1.00 V	±28.5 mV	0.9715	1.0285 V
50 mV	500.000 mV	500 mV	±14.25 mV	485.75	514.25 mV

4 Press the channel number key (bottom row) and set the `V/div` range and `position` from the first line of the table.

5 Set the supply voltage to 2.00 V as in the first line.

6 Readjust the `position` so the trace is as close to the horizontal center line of the graticule as possible after it has settled (averaging complete).

7 Read the position voltage. It should be at its original setting, within the limits given in the table. Record the reading in the Performance Test Record.

8 Repeat steps 4 through 7 for the other lines in the table.

9 With the channel keys (bottom row) set the active channel `off` and the next `on`.

10 Repeat steps 2 through 10 for any untested channels, setting the parameters of the channel being tested where appropriate.

If the test fails
Offset errors can be caused by the need for self-calibration. Perform self-calibration, 0. vertical cal, (see chapter 4, "Calibrating and Adjusting") before troubleshooting the instrument.

To test bandwidth

This test checks the bandwidth of the oscilloscope.

Specification

Repetitive (all models) dc to ≥500 MHz (equivalent time)

Real Time

HP 54520A dc to ≥125 MHz

HP 54540A dc to ≥125 MHz (3 or 4 CH on), dc to ≥250 MHz (1 or 2 CH on)

HP 54522A and 54542A dc to ≥500 MHz

Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Signal Generator	1—500 MHz at ≈200 mVrms	HP 8656B
Power Meter/Sensor	1—500 MHz ±3% accuracy	HP 436A/8482A
Power Splitter	outputs differ by <0.15 dB	HP 11667A
Cable	Type N (m) 24 inch	HP 11500B
Adapter	Type N (m) to BNC (m)	HP 1250-0082

Repetitive Test

1 Connect the equipment

a With the N cable, connect the signal generator to the power splitter input. Connect the power sensor to one output of the power splitter.

b With an N-to-BNC adapter, connect the other splitter output to the channel 1 input.

2 Press `Recall` , then press `Clr` to set the oscilloscope to default conditions. Set the following parameters.

Menu (hardkey)	Function/Parameter	Setting
Vertical (channel keys) (all channels)	(sensitivity)	100 mV/div
	(input R)	50Ω DC
Horizontal (Setup)	(time/div)	200 ns/div
	(mode)	repetitive
Display	(mode)	avg
	# of avg	32
	(graticule)	grid
Entry	Fine	(on)

3 Set the signal generator for 1 MHz at +5.0 dBm. The signal on the screen should be about two cycles at six divisions amplitude.

Note: Do not exceed 6 divisions when making the bandwidth check.

4 Initiate a V amptd measurement.

Press `(blue)` , `V amptd` , and `1` (channel number, entry menu).

5 After the measurement settles (averaging complete, about 10 seconds) note the Vamp (1) reading (bottom of screen): V_{1MHz} = _____ mV.

6 Set the power meter Cal Factor % to 1 MHz value from the cal chart on the probe. Then press dB[REF] to set a 0 dB reference.

7 Change the signal generator to 500 MHz and set the power meter Cal Factor to 500 MHz % value from the chart.

8 Adjust the signal generator amplitude for a power reading as close as possible to 0.0 dB(REL). Reading = _____.

9 Set the time/div to 2 ns/div.

10 After the measurement settles (averaging complete), note the V amptd (1) reading: V_{500MHz} = _____ mV.

11 Calculate the response using the formula:

$$\text{response(dB)} = 20 \log_{10} \frac{V_{500\,MHz}}{V_{1\,MHz}} = 20 \log_{10} _____ = _____ \text{ dB}$$

12 Correct the result from step 11 with any difference in the power meter from step 8. Observe signs. For example:

Result from step 11 = –2.3 dB

. Power meter reading = –0.2 dB(REL)

then true response = (–2.3)–(–0.2) = –2.1 dB

(_____) – (_____) = _____dB

13 The result from step 12 should be between +3.0 dB and –3.0 dB. Record the result in the Test Record.

14 Switch the power splitter from channel 1 to channel 2 input.

15 On the oscilloscope, set the following parameters.

Menu (hardkey)	Function/Parameter	Setting
Vertical (channel keys)	1	off
	2	on
Horizontal	(time/div)	200 ns/div
TRIG	source	2

16 Press `(blue)` , then press `Clr` . Repeat steps 3 through 16 for untested channels, setting the parameters of the channel being tested where appropriate.

Real Time Test

In the real time mode, the bandwidth is limited by the software; the hardware is unchanged. Therefore, testing real-time bandwidth is optional.

17 Press Horizontal `Setup` and set the mode to `realtime`.

18 Repeat steps 2 through 16, testing all vertical channels using as an upper frequency test limit the following:

HP 54522A and 54542A; 500 MHz

HP 54540A; 250 MHz (1 or 2 channels on), 125 MHz (3 or 4 channels on)

HP 54520A; 125 MHz

If the test fails
Failure of the bandwidth test can be caused by faulty attenuator or main assembly, or the need for high-frequency pulse response adjustment.

To test time measurement accuracy

This test uses a precise frequency source to check the accuracy of time measurement functions.

Specification Delta-t accuracy

Repetitive (≥8 averages) ±[(0.005% × delta-t) + (0.1% of full scale)+ 100 ps]
Real Time * ±[(0.005% × delta-t) + (0.2 × sample period)]

* The specification applies to bandwidth limited signals (tr = 1.4 × sample period). The sample period is defined as 1/(sample rate). The specification also applies to those automatic measurements computing time intervals on identical slope edges (like pos-pos, neg-neg).

Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Signal Generator	1-40 MHz, timebase accuracy - 0.25 ppm	HP 8656B Opt. 001
Pulse generator	tr from 1.0 to 2.8 ns, 280 mVp-p,,externally triggerable	HP 8161A
Cable	Type-N 24 inch	HP 11500B
Cable	BNC	HP 10503A
Adapter	Type N (f) to BNC (m)	HP 1250-0077

Repetitive Mode Procedure

This test checks time measurement in repetitive mode with averaging.

1 Set the HP 8656B signal generator to 40 MHz (25.0 ns period) and 800 mVrms.

2 Connect the output of the signal generator to the EXT INPUT of the HP 8161A pulse generator.

3 Connect the output of the pulse generator to the channel 1 input.

4 Set up the pulse generator.

Input Mode = TRIG
Ext Input = 50 ohm, Trig Level = centered
Delay = 0 s
Width = 12.5 ns
Leading Edge = 1.3 ns
Trailing Edge = 1.3 ns
High Level = 0.14 V
Low Level = -0.14 V

5 Press Recall , then press Clr to set the oscilloscope to default conditions.

6 Press the channel 1 key (bottom row). Use the impedance soft key to select 50Ω DC.

7 Press `Autoscale`, then set the following parameters.

Menu (hardkey)	Function/Parameter	Setting
Vertical (channel key)	(sensitivity)	100 mV/div
Horizontal	(time/div)	50 ns/div
(Setup)	(mode)	repetitive
Display	(mode)	avg
	# of avg	8

8 Press `Define meas`, then with the softkeys set `statistics` to `on`.

9 With the soft keys select `define`, `user defined`, and `measurements`.

For valid statistical data
In repetitive mode, measurement specifications are valid with eight or more acquisitions averaged. Statistics accumulated before the required number of averaged acquisitions may show the instrument to fail the specification. This is particularly true for minimum and maximum in this case since they are set by measurements taken with the fewest averages.

If the procedure above is followed exactly, the required number of acquisitions are averaged before statistics are turned on. If however, **Clear display** is pressed after statistics are turned on, averaging and statistics are restarted simultaneously and the result is erroneous data collected from the early averages.

If in doubt about the statistical data, after #Avg is complete press `Define meas`, select `meas`, and turn statistics `off` then `on`. This restarts the statistics without restarting averaging and the result is valid data.

10 Initiate a delay measurement.
Press `(blue)` `Δ Time` `1` `1`.

11 The Δ Time readings should be 25 ns ±601.3 ps; minimum 24.399 ns and maximum 25.601 ns. Record the minimum and maximum readings in the Performance Test Record.

12 Change the signal generator frequency to 100 MHz (10 ns period).

13 Set the time/div to 20 ns/div.

14 Clear the statistics.

- Press `Define meas`, select `measure`, and turn statistics `off` then `on`.

  or

- Press `(blue)` `Clr meas`, then press `(blue)` `Δ Time` `1` `1`.

15 The Δ Time delay readings should be 10 ns ±301 ps: minimum 9.699 ns and maximum 10.301 ns. Record the minimum and maximum readings in the Performance Test Record.

16 Change the signal generator frequency to 20 MHz (50 ns period).

17 Set the time/div to 100 ns/div.

18 Clear the statistics as in step 14.

19 The Δ Time readings should be 50 ns ±303 ps; minimum 49.697 ns and maximum 50.303 ns. Record the minimum and maximum readings in the Performance Test Record.

20 Change the signal generator frequency to 1 MHz (1.0 µs period).

21 Change the Pulse generator width to 500 ns.

22 Set time/div to 1 µs/div.

23 The Δ Time readings should be 1 µs ±3.05 ns; minimum 996.95 ns and maximum 1.00305 µs. Record the minimum and maximum readings in the Performance Test Record.

24 Press `Define meas` and select define. Press the sixth softkey ("to" key) to select edge #2, and enter 6.

25 The Δ Time readings should be 5 µs ±3.25 ns; minimum 4.99675 µs and maximum 5.00325 µs. Record the minimum and maximum readings in the Performance Test Record.

Real Time Mode Procedure

This procedure continues from the previous one. The signal is changed to a frequency less sensitive to interference from commonly used frequencies.

1 Change the signal generator frequency to 25.31646 MHz (39.49999 ns period).

2 Change the pulse generator width to 12.5 ns.

3 If you are testing an HP 54520A, change the pulse generator rise time to 2.8 ns.

4 Change the following parameters on the oscilloscope.

Menu (hardkey)	Function/Parameter	Setting
Horizontal	(time/div)	50 ns/div
	delay	0.00000
(Setup)	(mode)	real time
	record length	8192

5 Press `Define meas` , select **`define`**, and set **`to`** key to edge # 11.

6 Press `(blue)` `Period` `1` .

7 Period should read:

Instrument	Reading	Min Reading	Max Reading
HP 54520A	39.5 ns ±401.98 ps	39.098 ns	39.902 ns
HP 54522A/54540A/ 54542A	39.5 ns ±201.98 ps	39.298 ns	39.702 ns

Record the minimum and maximum readings in the Performance Test Record.

8 The Δ Time should read:

Instrument	Reading	Min Reading	Max Reading
HP 54520A	395 ns ± 419.75 ps	394.580 ns	395.420 ns
HP 54522A/54540A/ 54542A	395 ns ± 219.75 ps	394.780 ns	395.220 ns

Record the minimum and maximum readings in the Performance Test Record.

9 Select measure and set statistics to `off`.

10 Press `Stop/Single` (to stop acquisition), then press Single once.

11 Set the horizontal scale to 1.00 µs/div.

12 Press `Define meas` , select define, and change edge # 11 to edge # 101.

13 The Δ Time should read 3.94999 µs ±4.198 ns: minimum 3.9458 µs and maximum 3.9542 µs. Record the reading in the Performance Test Record.

14 Change edge # 101 to edge # 201.

15 The Δ Time should read 7.89998 µs ±4.395 ns: minimum 7.8956 µs and maximum 7.9044 µs. Record the reading in the Performance Test Record.

If the test fails
Timing failures are caused by a defective main assembly. However, before troubleshooting the oscilloscope, be sure signal sources are not at fault. While catastrophic failures are usually caused by an instrument failure, marginal timing failures are usually caused by test equipment inaccuracies or procedural errors.

To test trigger sensitivity

This test checks channel and external triggers for sensitivity at rated bandwidth.

Specification	dc to 100 MHz	100 MHz to 500MHz
Internal	0.5 div	1.0 div
External	0.0225 × signal range	0.045 × signal range
Auxiliary	dc to 50 MHz, 250 mV_{p-p}	

Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Signal Generator	100 and 500 MHz, 30-80 mVrms output	HP 8656B
Power Splitter	outputs differ by <0.15 dB	HP 11667A
Termination	BNC feedthrough, 50 Ω	HP 10100C
Cable	Type N (m) 24 inch	HP 11500B
Cable	50 Ω BNC 36 inch	HP 10503A
Adapter	Type N (f) to BNC (m)	HP 1250-0077
Adapter	Type N (m) to BNC (m)	HP 1250-0082
Adapter	Type N (m) to BNC (f)	HP 1250-0780
Adapter	BNC tee (m)(f)(f)	HP 1250-0781

Internal Trigger Test

Perform this test on all vertical channels.

1 Press `Recall` , then press `Clr` to set the oscilloscope to default conditions. Set the following parameters

Menu (hardkey)	Function/Parameter	Setting
Vertical	1	on
(channel key)	others	off
(all)	(sensitivity)	200 mV/div
	(input R)	50Ω DC
Horizontal	(time/div)	5 ns/div
(Setup)	(mode)	repetitive
Display	(mode)	avg
	# of avg	16
	(graticule)	grid

2 With an N cable and N-to-BNC adapter, connect the signal generator to the channel 1 input.

3 Set the signal frequency to 100 MHz and output level for 0.5 divisions of vertical deflection.

The voltage markers can be used to set a 0.5 div reference. Press Marker and turn the markers on. Set source x1, y1 and source x2, y2 to the channel being tested. Set the y1 marker to +50 mV and the y2 marker to -50 mV.

4 Adjust the trigger level for a stable display.

5 The test passes if triggering is stable. Record the result in the Performance Test Record.

6 Set the signal frequency to 500 MHz and the output level for 1.0 division of vertical deflection.

7 Set the horizontal to 1 ns/div.

8 Adjust the trigger level for a stable display.

9 The test passes if triggering is stable. Record the result in the Performance Test Record.

10 Connect the signal generator to the channel 2 input.

11 Set up the oscilloscope.

Menu (hardkey)	Function/Parameter	Setting
Vertical (channel key)	1 2	off on
Horizontal	(time/div)	5 ns/div
Trigger (Setup)	source	2

12 Test the other channels.

- For the HP 54520 and 54722, repeat steps 2 through 9 for channel 2.
- For the HP 54540 and 54742, repeat steps 2 through 11 for channels 2, 3, and 4, setting the tested channel's parameters where appropriate.

External Trigger Test

This test is necessary only for the HP 54520A and 54522A.

1 Connect the equipment.

a With the N cable, connect the signal generator to the power splitter input.

b Using an N-to-BNC adapter and BNC cable, connect one splitter output to the channel 1 input.

c Press the channel 1 select button and set the input resistance to 50 Ω.

d Connect the second splitter output to the Ext trigger input.

2 Set the signal generator frequency to 100 MHz and output level to 32 mVrms (90 mVp-p from the generator, 45 mVp-p into the trigger).

3 Press Autoscale .

4 Press the Ext trigger button (bottom row) and set the range to ±1 V and the input resistance to 50Ω DC.

5 Press the Trigger Setup and set the source to External.

6 Adjust the trigger level for a stable display.

7 The test passes if triggering is stable. Record the result in the Performance Test Record.

8 Set the signal generator frequency to 500 MHz and output level to 64 mVrms (180 mVp-p from the generator, 90 mVp-p into the trigger).

9 Adjust the trigger level for a stable display.

10 The test passes if triggering is stable. Record the result in the Performance Test Record.

Auxiliary Trigger Test

The auxiliary trigger input is on the rear panel of the oscilloscope. The input impedance of the aux trigger is 4 kΩ so, to avoid reflections, the test is done without other terminations.

1 With an N-to-BNC adapter and BNC cable, connect the signal generator to the channel 1 input.

2 Set the signal generator for 50 MHz .

3 Set the channel 1 input to `1 MΩ` (50 Ω is not lit) and press `Autoscale` .

4 Set the channel 1 sensitivity to `50 mV/div` and set the signal generator for 5 divisions of signal, 250 mV_{p-p}.

5 Disconnect the signal cable from the channel 1 input and connect it to the Aux trigger input on the rear panel.

6 Press the Trigger `Setup` and set the `source` to `Auxiliary`.

7 Set the trigger level to 0.000 V. Only `running` should appear in the status in the upper left corner of the display.

If the status is `running-auto triggering` or `running-awaiting trigger`, the oscilloscope is not triggered.

8 The test passes if the oscilloscope triggers. Record the result in the Performance Test Record.

If a test fails

Failure of the internal trigger or external trigger sensitivity tests can be caused by a defective main assembly or attenuator. Failure of the auxiliary trigger sensitivity is caused by a problem on the main assembly or a bad input cable. If you need further troubleshooting information, go to chapter 5, "Troubleshooting."

To test the oscillator output

These tests are optional. The oscillator outputs are not specified in the instrument performance specifications. The values given are typical. Results are not recorded in the Performance Test Record.

Equipment Required

Equipment requirement is not critical and choices are at the discretion of the user. A high quality oscilloscope should be sufficient.

Procedure

1 Press `Recall` , then press `Clr` to set the oscilloscope to default conditions.

2 Use a BNC cable to connect the rear panel AC cal output to the channel 1 input of the oscilloscope under test and press `Autoscale` .

3 Make automatic amplitude and frequency measurements of the signal.
Press `(blue )` `V amptd` `1` for the amplitude
and press `(blue)` `Frequency` `1` for the frequency.

4 The signal into 1 MΩ should be an approximately 800 mV_{p-p} square wave at approximately 500 Hz. Into 50 Ω the amplitude is approximately 400 mV_{p-p}.

5 Disconnect the AC cal output from the channel 1 input and connect it to another oscilloscope.

6 Press `Utility` , then press **`service menu`** to turn on **`cal select 0`** (0. 10 MHz timebase to AC BNC).

7 The signal will be approximately 10 MHz and 800 mV_{p-p} into 1 MΩ.

HEWLETT PACKARD

HP 54520A/54522A/54540A/54542A Oscilloscopes

Model Number _____ Tested by _____

Serial Number _____ Work Order No. _____

Recommended Test Interval - 1 Year/2000 hours Date _____

Recommended next testing _____ Temperature _____

Test	Limits		Results			
dc Calibrator Amplitude	5.000 V	4.990 to 5.010 Vdc	_____			
			Channel 1	**Channel 2**	**Channel 3**	**Chan 4/Ext**
Input Resistance	50 Ω	49.5 Ω to 50.5 Ω	_____	_____	_____	_____
	1 MΩ	990 kΩ to 1.010 MΩ	_____	_____	_____	_____
Voltage Measurement Accuracy	**Range** **Supply**	**Limits**				
	5 V/div 30 V	29.34 V to 30.66 V	_____	_____	_____	_____
	5 V/div 15 V	14.34 V to 15.66 V	_____	_____	_____	_____
	5 V/div 5 V	4.34 V to 5.66 V	_____	_____	_____	_____
	200 mV 1.2V	1.1736 V to 1.2264 V	_____	_____	_____	_____
	200 mV 600 mV	573.6 V to 626.4 V	_____	_____	_____	_____
	200 mV 300 mV	173.6 V to 226.4 V	_____	_____	_____	_____
	10 mV 60 mV	58.68 mV to 61.32 mV	_____	_____	_____	_____
	10 mV 30 mV	28.68 mV to 31.32 mV	_____	_____	_____	_____
	10 mV 10 mV	8.68 mV to 11.32 mV	_____	_____	_____	_____
	7 mV 42 mV	41.076 mV to 42.924 mV	_____	_____	_____	_____
	7 mV 21 mV	20.076 mV to 21.924 mV	_____	_____	_____	_____
	7 mV 7 mV	6.076 mV to 7.924 mV	_____	_____	_____	_____
Offset Accuracy	**Range**	**Offset** **limits**				
	200 mV/div	2.0 V 1.943 to 2.057 V	_____	_____	_____	_____
	100 mV/div	1.0 V 0.9715 to 1.0285 V	_____	_____	_____	_____
	50 mV/div	500 mV 485.75 to 514.25 mV	_____	_____	_____	_____

Test	Limits		Results			
Bandwidth		**Down from reference:**	**Channel 1**	**Channel 2**	**Channel 3**	**Channel 4**
	Repetitive	<3.0 dB at 500 MHz				
	Realtime					
	HP 54520A	<3.0 dB at 125 MHz				
	HP 54540A (1 or 2 chans on)	<3.0 dB at 250 MHz				
	HP 54540A (3 or 4 chans on)	<3.0 dB at 125 MHz				
	HP 54522A/54542A	<3.0 dB at 500 MHz				
Time Measurement Accuracy	**Repetitive Mode**	**ΔTime**	**Minimum**		**Maximum**	
	25 ns	24.399 to 25.601 ns				
	10 ns	9.699 to 10.301 ns				
	50 ns	49.697 to 50.303 ns				
	1 µs	996.95 to 1.00305 µs				
	5 µs	4.99675 to 5.00325 µs				
	Realtime Mode	**Period**				
	HP 54520A	39.098 to 39.902 ns				
	HP 54522A/40A/42A	39.298 to 39.702 ns				
		ΔTime(edge#11)				
	HP 54520A	394.580 to 395.420 ns				
	HP 54522A/40A/42A	394.780 to 395.220 ns				
		ΔTime (edge#101)	**Reading**			
	All models	3.9458 to 3.9542 µs				
		ΔTime (edge#201)				
	All models	7.8956 to 7.9044 µs				
Trigger Sensitivity	**Mode**	**Stable Trigger On:**	**Pass/Fail**			
	Internal Trigger		**Channel 1**	**Channel 2**	**Channel 3**	**Channel 4**
		0.5 div at 100 MHz				
		1.5 div at 500 MHz				
	External Trigger (HP 54520 and 54522 only)					
	on ±1 V range:	45 mVp-p at 100 MHz				
		90 mVp-p at 500 MHz				
	Auxiliary Trigger	250 mVp-p at 50 MHz				

4 Calibrating and Adjusting

4

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Calibrating and Adjusting

Calibrating and Adjusting

This chapter provides firmware and hardware calibration and adjustment procedures for the HP 54520 and 54540-Series oscilloscopes. Primary adjustment groups are the following:

- Power Supply Adjustment
- Main Assembly Calibration and Adjustment
- CRT Monitor Assembly Adjustment.

Equipment Required

Equipment required for adjustments is listed in table 1-1, "Recommended Test Equipment", in chapter 1 of this manual. Any equipment that satisfies the critical specification listed in the table may be substituted for the recommended model. Equipment for individual procedures is listed at the procedure.

Calibration Interval

There are two types of calibration for the HP 54520 and 54540-Series oscilloscopes. The firmware calibration is the self cal (self-calibration). Self-calibration should be done every year, or every 2,000 hours of operation, whichever comes first. The hardware calibration consists of adjustment of the power supply, high-frequency pulse response, and CRT display. These adjustments only need to be done under circumstances set by certain needs, which are explained in other areas of this guide.

The need for calibration or adjustment will also depend on your experience.

For replacement assemblies, adjustments are set at the factory when assemblies are tested. However, some adjustment may be necessary after an assembly has been put into the instrument. Usually the only assembly that requires adjustment is the assembly replaced.

Cal RAM Checksum Error

If power is applied to the instrument and the message "cal ram checksum error re-cal instrument" is displayed, all firmware calibration procedures must be performed. See "To calibrate the firmware" in this chapter.

If the instrument does not pass the firmware calibration, repair is necessary.

Operating Hints

Some knowledge of operating the HP 54520 and 54540-Series oscilloscopes is helpful. However, procedures are written so that little experience is necessary. The following hints will speed progress of the procedures.

When using many averages, it often takes awhile for a waveform display to stabilize after a change. When a front panel control on the oscilloscope is changed, averaging automatically restarts. When the input signal or an adjustment is changed, the

instrument must average new data with the old, so it takes longer for the waveform to stabilize. Press `Clear display` while changing input signals or adjustments. Clearing the display restarts averaging, which gives a quicker indication of the result of the change.

Key-Down Powerup

For a key-down powerup, any front panel key is held depressed while power is cycled. It is the surest way to reset the instrument to default conditions. The key-down powerup is also the first step toward loading new software through the disk drive.

The first message during the key-down powerup asks if you want to update system code (see "Loading New Software" below). If you want to continue with a normal key-down powerup, you can press any key other than the shift key.

Loading New Software

This oscilloscope stores its operating system code in electrically eraseable PROM (EEPROM). New code is loaded into the oscilloscope by using the disk drive. A disk with the current code is shipped with the instrument. It is rarely necessary to reload the code. You should load the code only if prompted by a troubleshooting procedure, or if you want to load a later version of code.

The operating system code is loaded through the key-down powerup. The first message during the key-down powerup asks if you want to update system code. If you do want to update code, press the `(blue)` key. The display will prompt you for any further steps you must do.

Calibration and Adjustment Procedures

The procedures start with the next paragraphs. Unless specified elsewhere, procedures must be followed in the order given. Display adjustments are optional and independent of other procedures.

CAUTION

Warm up the instrument for 30 minutes before starting adjustment procedures. Failure to allow warm-up may result in inaccurate calibration.

WARNING

SHOCK HAZARD!
Read the Safety information at the back of this guide before performing adjustment procedures. Failure to observe safety precautions may result in electrical shock.

Power Supply

This section provides an adjustment procedure for the power supply.

To adjust the power supply

The power supply should rarely need adjustment. Perform this procedure only if the supply has been checked and is known to be incorrect.

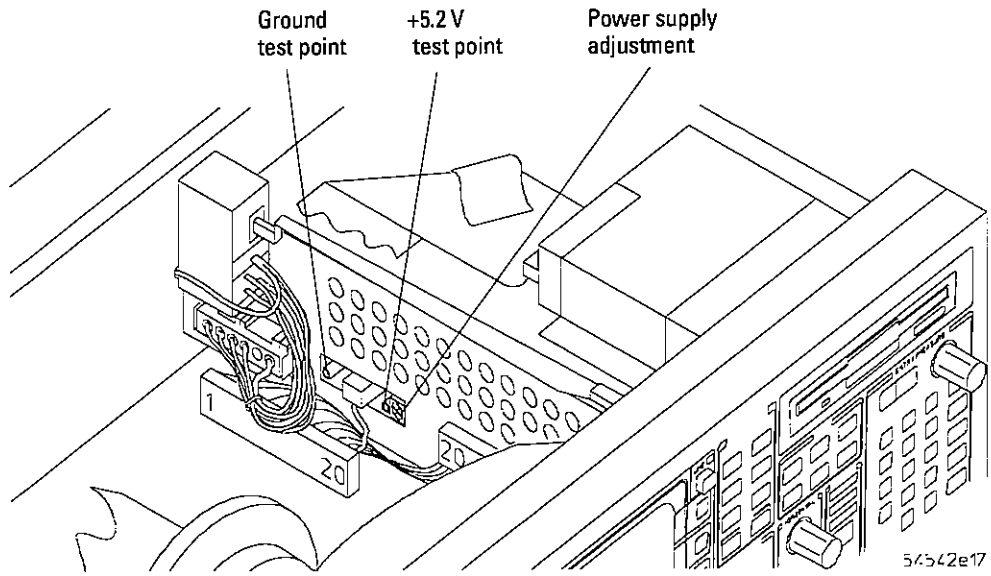
Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Digital Voltmeter	Accuracy ±0.05%	HP 34401A

Procedure

1 Disconnect the instrument power cord and remove the cover.
If necessary, refer to the procedures in chapter 6, "Replacing Assemblies."

2 Refer to figure for testpoint and adjustment locations.



Power Supply Adjustment Location

3 Connect the common lead of the voltmeter to COM test point.

4 Connect the positive lead of the voltmeter to +5.20 V test point.

5 Connect the oscilloscope power cord and set power switch to ON.

6 If the voltmeter does not read between 5.180 V and 5.220 V, adjust for 5.200 V.

The main assembly procedures calibrate and adjust the acquisition system of the instrument. Calibration involves running the self-calibration. The main assembly adjustments set the high-frequency pulse response of each channel.

There is no preparation required for calibrating the instrument. However, if it is necessary to adjust the high-frequency pulse response, the cover must be removed and the disk drive and power supply moved to allow access to the adjustments on the main assembly. Moving the power supply requires the use of an extender cable. See "To adjust the high-frequency pulse response" in this chapter.

To load the default calibration

The default calibration factors are loaded to give a known base for the following hardware and firmware calibration.

CAUTION Once the default cals are loaded, all firmware calibrations must be done. This includes all calibrations in the self cal menu (0. vertical, 1. delay, 2. time null, and 3. logic trigger). Failure to run the calibrations after loading default cals will result in an uncalibrated instrument.

Since all calibration must be done in order, firmware calibrations will be presented in the proper place in the procedures.

1. Press `Utility` , then press **`service menu`**.
2. Press **`cal select`** twice to select **`cal select 2`** (2. default cal).
3. Set the rear panel Calibration switch to Unprotected (up).
4. Press **`start cal`**. A caution message will be displayed indicating the cal factors will be overwritten with default values.
5. Press **`continue`**. The status message above the menu will indicate default cal has been loaded.
6. Leave the rear panel switch in Unprotected position for firmware calibration procedures to be performed later in this chapter.

To adjust the high-frequency pulse response

This procedure optimizes the high-frequency pulse response, so the instrument will meet the bandwidth specification.

When to use this procedure
This procedure should not be performed as a part of routine maintenance. Typically, a high-frequency pulse adjustment needs to be done only when a channel fails the bandwidth performance test or when an attenuator, acquisition hybrid, or the main assembly has been changed (new combination of attenuators, hybrids, and PC board). Only adjust the channels involved with the failure or repair.

Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Pulse Generator	t_r <175 ps	Picosecond Pulse Labs 1110B Driver/1107A or 1107B Head
Extender Cable	No substitute	54542-61609
Adapter	SMA 3.5 (m) to BNC (m)	HP 1250-1787

Set up the equipment

Use this procedure to gain access to the adjustments. It is necessary to raise the supply to get clearance above the main assembly. If necessary, refer to the procedures in chapter 6, "Replacing Assemblies."

1 Remove the power cord and the cover.
2 Remove the two screws that secure the disk drive to the top of the power supply and set the disk drive to the side while you remove the supply.
3 Disconnect the three cables on the left side of the power supply.
4 Remove the two locking pins and slide the power supply out of the instrument.
5 Disconnect the standard power supply cable from the main assembly and connect the extender cable.

CAUTION Make sure that the instrument fan or an external fan is used to circulate the air through the power supply. If the supply gets too warm, the thermal cut-out in the supply will shut the supply off.

6 Suspend the supply in the instrument cabinet.

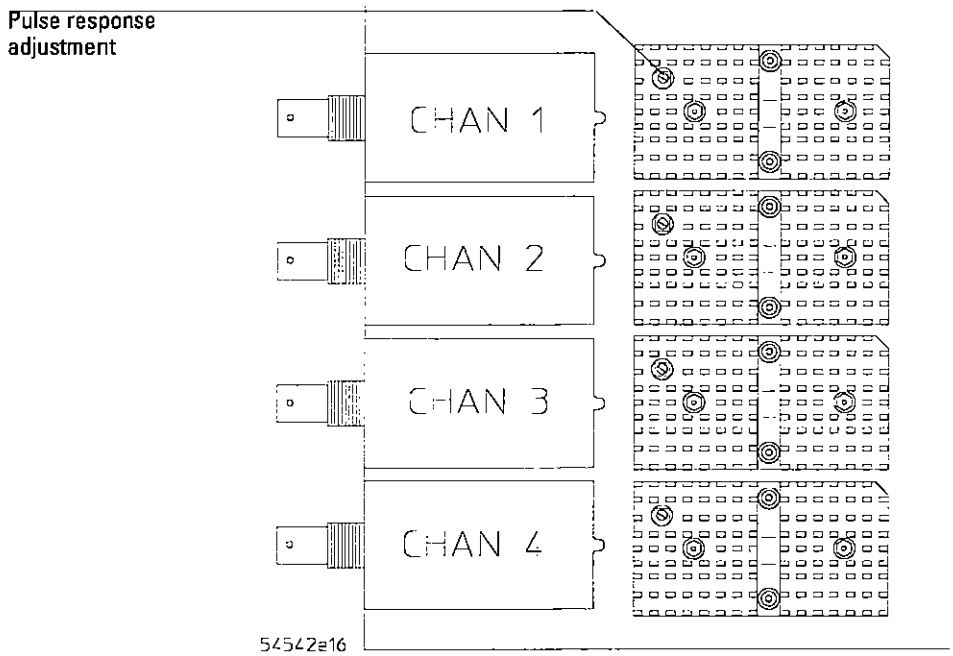
The power supply has two flanges that normally support it in the grooves in the cabinet If you place the supply with the flanges supported by the top of the cabinet (front and rear), it will hang so it is partially in the airflow from the fan, you can connect the line filter cable to the supply, and you can still get clearance to the adjustments on the main assembly

7 Connect the Extender Cable to the power supply.
8 Reconnect the line filter cable to the power supply.

9 Connect the mains power cable and apply power.

Adjustment Procedure

Perform this procedure on the necessary channel only. The adjustment for each channel is reached through a hole in the heatsink over the acquisition hybrid for that channel Use the following illustration to locate the adjustments.



Main Assembly Adjustment Locations

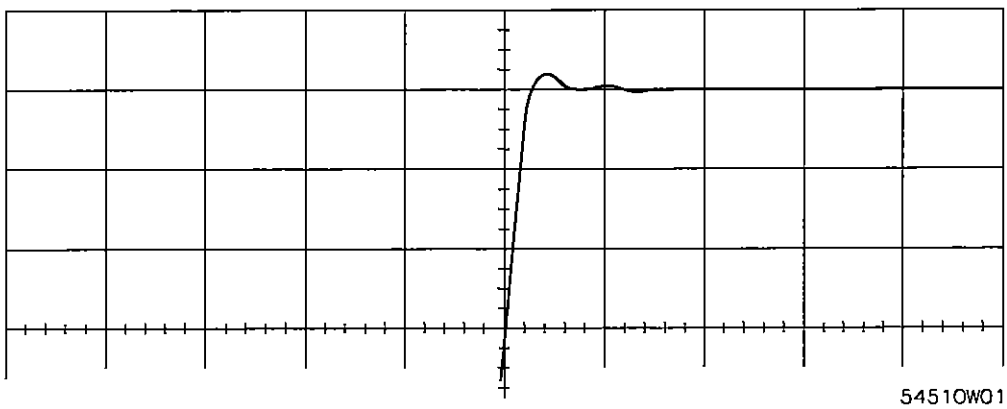
1 Connect the pulse generator output to the input of the channel needing adjusting.
2 Press the appropriate channel number key (bottom row) to select the channel menu.
3 Use the input resistance softkey (second from bottom) to select `50Ω DC`.
4 Press `Autoscale` , then set the following parameters.

Menu (hardkey)	Parameter	Setting
Vertical (channel key)	(sensitivity)	40 mV/div
Horizontal (Setup)	(time/div)	5 ns/div
	(mode)	repetitive
Display	# of avg	16
	(graticule)	grid

5 If the pulse edge is not on screen, adjust the delay to set it near center screen.

6 Press the channel number key and adjust the position to place the flat part of the pulse top over the grid line, one division from the top of the display.

7 Adjust the resistor to extend the peak over the grid line, so that the overshoot is about 3%, a little less than one vertical minor division, as shown in the illustration. (One vertical minor division is about 4% of a six division signal.)



When the resistor is adjusted, the gain changes. It may be necessary to use the position to reposition the pulse top to the grid line.

There is no specification for pulse response. However, if overshoot is more than about 3% (about 3/4 minor division), use the resistor to reduce it slightly. If the instrument fails the bandwidth test, use the resistor to increase overshoot slightly.

8 If necessary, repeat steps 1 through 8 on any other channels needing adjustment.

9 Perform the bandwidth test (Performance Tests) on any channels that have been adjusted.

10 If you have readjusted the pulse response, the channel gain has changed. You must recalibrate the channel (self cal) as given in the next procedure, "To claibrate the firmware."

11 Reassemble the instrument.

Instrument warm-up
Before the Firmware Calibration, the next procedure that is part of a routine calibration, you will need to let the instrument warm up for half an hour with the cover installed.

To calibrate the firmware

The firmware calibration uses signals generated in the instrument to calibrate channel sensitivity, offsets, and trigger parameters.

Equipment Required

Equipment	Critical Specifications	Recommended Model/Part
Cable	BNC 50 Ω 36 inch	HP 10503A
Cable (4)	BNC 50 Ω 9 inch (equal length)	HP 10502A
Adapter (3)	BNC tee (m)(f)(f)	HP 1250-0781
Adapter	BNC (f)(f)	HP 1250-0080

Calibration protection
The rear panel Calibration switch must be set to **Unprotected** for these procedures. If the entire adjustment procedures are being performed, the switch was set to Unprotected in a previous procedure.

CAUTION

The Firmware Calibration should only be done after the instrument has run for one half hour at ambient temperature with the cover installed. Calibration of an instrument that has not warmed up may result in performance test failure.

Self-Calibration

Default calibration factors must be loaded before starting self calibration. However, if you have been doing a complete calibration procedure, defaults were loaded just before the pulse response adjustment.

Calibration time
It will take 14 to 16 minutes to calibrate an individual vertical channel. If all channels are calibrated at the same time (**all** is selected), the calibration time is considerably less than calibrating all channels individually. Typically, calibration using **all** will calibrate the entire vertical in about 25 minutes without any operator intervention. Calibrating the time and trigger functions will take one or two additional minutes and requires a person to make cable connections during the procedure.

1 Perform a key-down powerup by cycling the instrument power while holding down any front-panel key.

The display will prompt you to press any key (other than the shift key) to continue with a normal key-down powerup.

2 If you have not done so, set the Calibration protect switch on the rear panel to Unprotected.

3 Check that default calibration factors are loaded.
Press `Utility` , then press `service menu`.

4 If default calibration factors are not loaded ("D"s in the table on the screen), load them.
Select `2. default cal`, and press `start cal` then `continue`.

5 Press `exit menu` then `self cal menu`. `Cal select 0` (0.vertical) should be selected.

6 Press `channel` to select `all`, then press `start cal` and follow the instructions on the display.

Calibrating individual channels or all
These calibrations may be done individually, but using **all** (when available), and connecting all inputs at once avoids operator interaction between calibrations. It also shortens the total calibration time (see the "Calibration Time" sidebar on the previous page).

If the entire calibration procedure fails while running **all**, run the calibrations individually. If one input is loading the cal signal (an input stuck in 50 Ω for example), calibration will fail for all inputs. Individual calibration will isolate the failure.

7 After completing vertical cals, press `cal select` to select `cal select 1` (1.delay).

8 Press `channel` to select channel 1, then press `start cal` and follow the instructions on the display.

9 When the channel 1 calibration is complete, select the other channels in turn and follow the instructions on the display.

10 Messages will be displayed as each calibration routine is completed to indicate calibration has passed or failed.

11 When the delay cal is complete, press `cal select` to select `cal select 2` (2.time null).

12 Press `start cal` and follow the instructions on the display.

13 Channels 2, 3, and 4 are calibrated against channel 1 As each pair of channels completes calibration, select the next and press `continue`.

14 When time null calibration is complete, press `cal select` to select `cal select 3` (3.logic trigger).

15 Press `start cal` and follow the instructions on the display.

16 Return to the start of the self cal menu (press `cal select`) . Note that the entire calibration matrix is filled with "P," and that all tests have passed.

17 After calibration has been completed, switch the rear-panel Calibration switch to Protected (down).

If calibration fails
Go to chapter 5 "Troubleshooting."

These adjustments optimize the characteristics of the CRT Display.

This procedure should not be performed as a part of routine maintenance. Perform the procedure only when the display has obvious differences from the example in the figure. Skip any part of the procedure when the display meets the requirement.

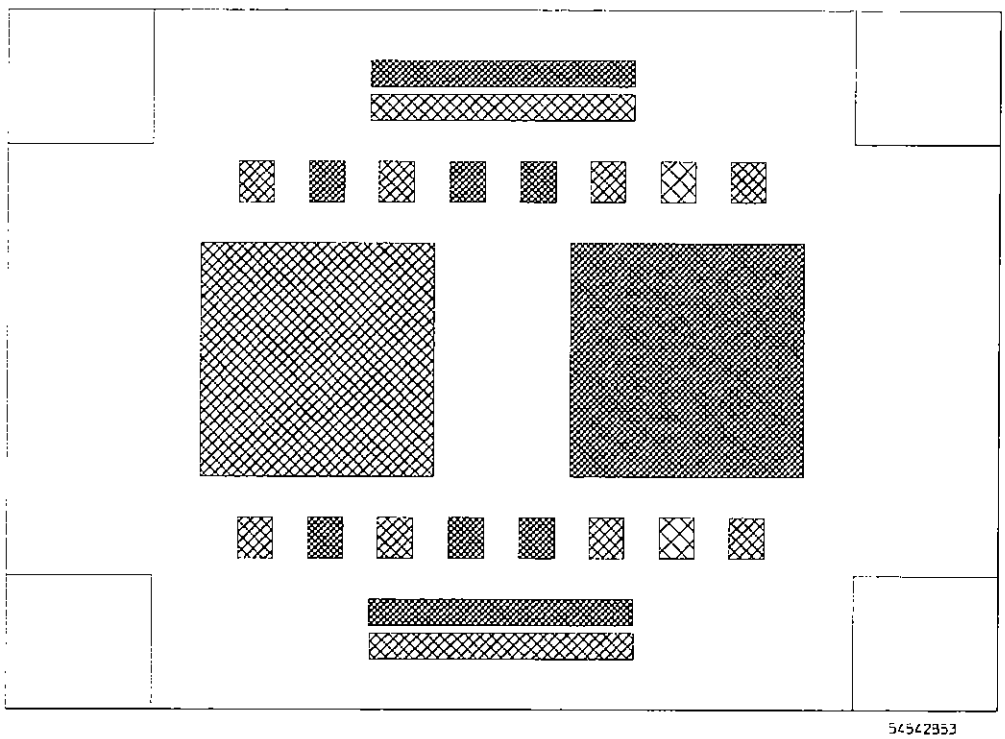
To adjust the display

1 Display the CRT test pattern.

a Press `Utility` , then press **`selftest`**.

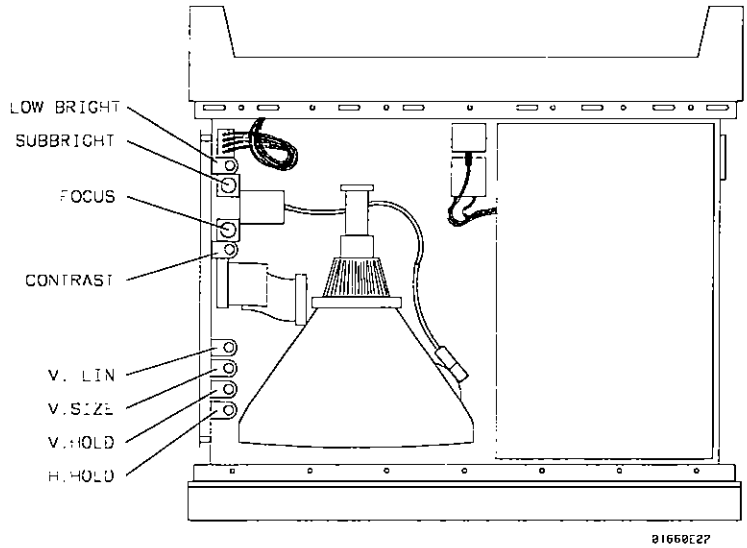
b Select **`misc`** with the top softkey, then select **`crt test`** with the second softkey.

c Press **`start test`**.



Display Test Pattern

2 Refer to the next figure for adjustment locations.



Display Adjustment Locations

3 Adjust V-HOLD, if necessary, for vertical synchronization.

4 Adjust H-HOLD, if necessary, for the best compromise between horizontal synchronization and horizontal position (horizontal centering that is still synchronized).

5 Adjust the display rotation.

The rotation of the display is often dependant on the orientation of the instrument to the earth's magnetic field. If the display needs adjusting, it should be adjusted with the same orientation as it will have during use.

a Loosen the clamp at the rear of the CRT yoke.

b Rotate the yoke so the lines of the display are parallel to the sides of the bezel.

c Carefully tighten the clamp on the yoke.

6 Set the rear-panel Intensity to maximum brightness.

7 Adjust the sweep board SUB-BRIGHT control to the highest setting where you cannot see the underlying raster.

During this adjustment, shade the display to avoid as much ambient light as possible.

LOW BRIGHT is used to set the minimum display brightness. It is best to leave it at the factory setting. If LOW BRIGHT has been mistakenly adjusted, set the rear-panel Intensity to minimum and adjust LOW BRIGHT for a barely discernable display in normal ambient light.

8 Turn the rear-panel Intensity to decrease intensity to a comfortable viewing level. The position of the Intensity adjustment should be at about 3/4 of its maximum range.

9 Adjust the CONTRAST for the best contrast betweent the dim and bright blocks on screen, ensuring text is legible in the dim blocks at the top and bottom of the screen.

10 Adjust FOCUS for a sharp percent symbol (%) in the top and bottom blocks of text.

11 Adjust V-LIN for equal height of the top and bottom corner squares. Square height should be approximately 25 mm.

12 Adjust V-SIZE to make the top and bottom borders of the screen approximately 1 cm.

5

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Troubleshooting

Troubleshooting

This section provides troubleshooting information for the HP 54520 and 54540 series oscilloscopes. The service strategy of this instrument is replacement of defective assemblies. The main assembly can be replaced on an exchange basis.

There are three main areas in this chapter. The troubleshooting helps you find a defective assembly when the instrument fails. After the troubleshooting are several pages that give an overview of the utility menus. Last is a copy of the registration form that you can print out of the instrument.

Safety

Read the Safety Summary at the front of this manual before servicing the instrument. Before performing any procedure, review it for cautions and warnings.

WARNING

Maintenance should be performed by trained service personnel aware of the hazards involved (for example, fire and electric shock). Lack of training and awareness of the hazards could result in electrical shock. When maintenance can be performed without power applied, the power cord should be removed from the instrument.

Tools Required

Just the normal tools used when troubleshooting electronic equipment are needed. A good digital multimeter and an oscilloscope with about a 100 MHz bandwidth should be sufficient.

If you need to remove and replace assemblies, you may need some of the hand tools listed in chapter 6, "Replacing Assemblies."

ESD Precautions

When using any of the procedures in this chapter, you should use proper ESD precautions. As a minimum you should place the instrument on a properly grounded ESD mat and wear a properly grounded ESD wrist strap.

Keystroke Conventions

To guide you while setting up the oscilloscope, the following conventions are used to represent keystrokes and other interactions with the instrument:

Text in a box, such as `Autoscale` or `Utility`, represents hardkeys, those defined by text on the front panel. It may be a shifted key.

Bold text in a typewriter font, such as **`Display`** or **`Calibrate...`**, represents text on the CRT screen and may be a softkey you should press or a message to consider.

Default Setup

A Default Setup is provided to assure the instrument setup is in a known default state. The default setup prevents previous setups from interfering with the next test. It also simplifies the instrument set up procedure. Use the default setup when a procedure requires it.

To set the instrument to the default state:

1 In the CONTROL section of the instrument, press `Recall` .

2 In the ENTRY keys, press `Clr` .

Key-Down Powerup

The key-down powerup is a more forceful reset than the default setup. It is usually used before self cal or when troubleshooting. It is also the first step toward loading new software through the disk drive.

1 Hold any front panel key depressed.

2 Cycle the power while the key is depressed.

3 When the display becoms visible, release the key, then press any key *except* the `(blue)` key.

The first message during the key-down powerup asks if you want to update system code. If you want to continue with a normal key-down powerup you press any key other than the shift (blue) key.

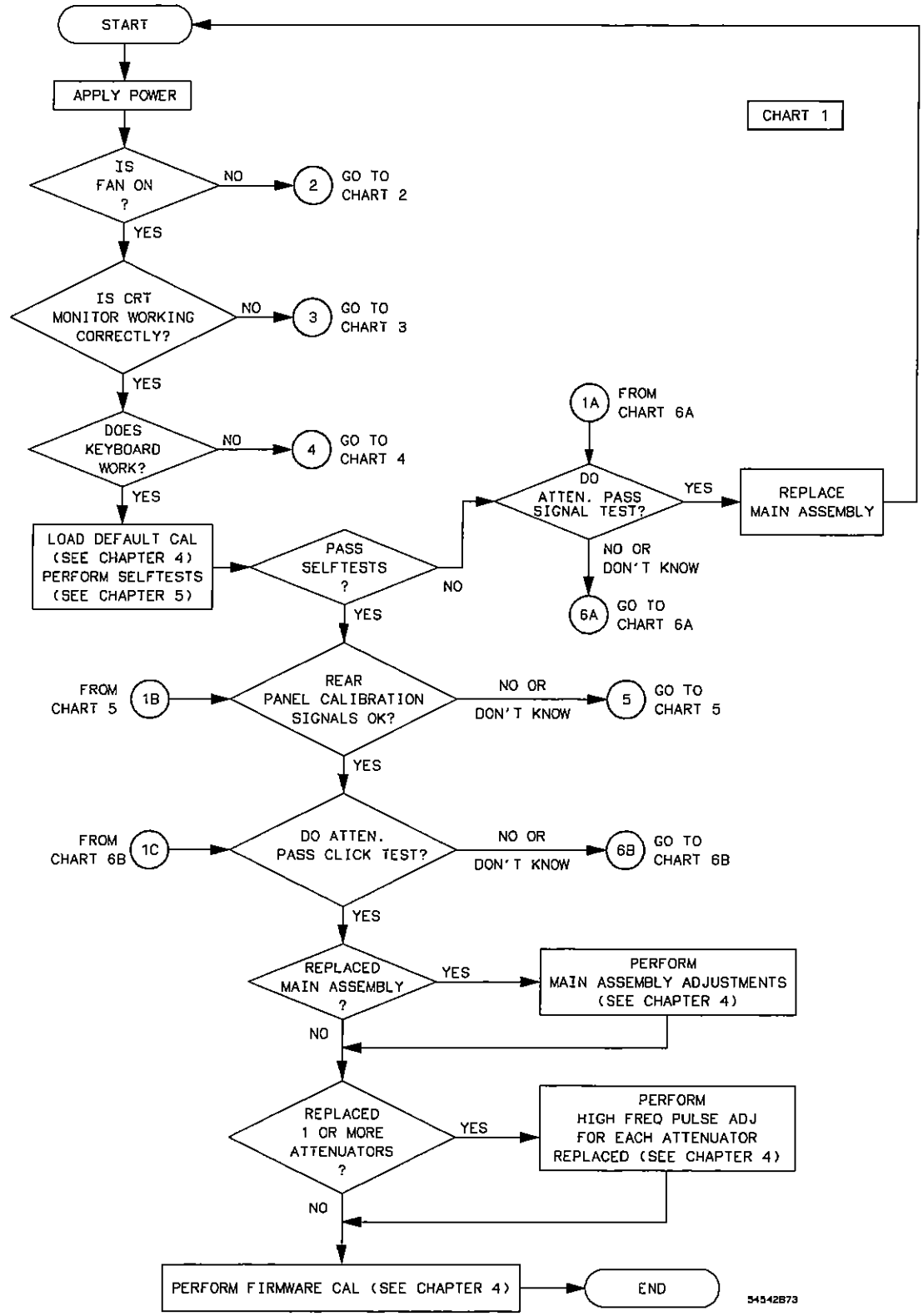
To troubleshoot the instrument

The troubleshooting is used to isolate problems to a faulty assembly. When the faulty assembly has been located, use the disassembly/assembly procedures in chapter 6 to help direct replacement of the assembly.

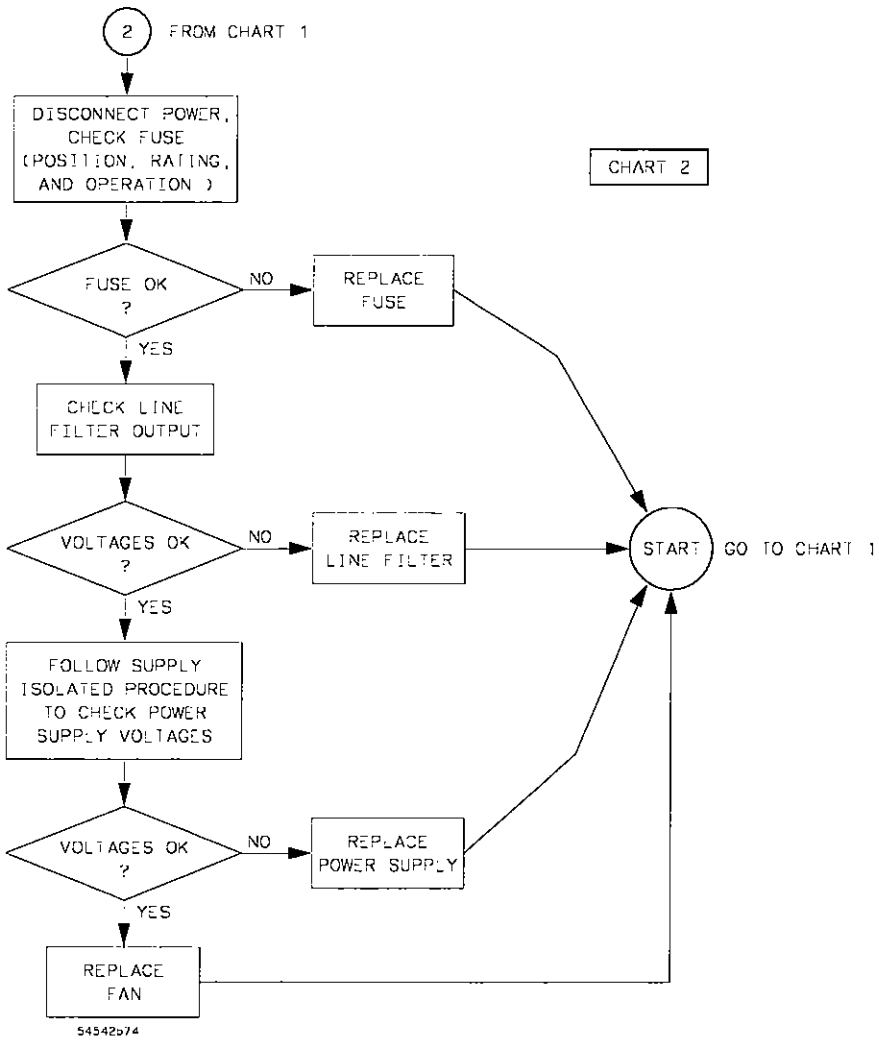
The trouble isolation flowcharts are the troubleshooting guide. Start with the flowcharts when repairing a defective instrument.

The flowcharts refer to other tests, tables, and procedures to help isolate trouble. The circled numbers on charts indicate the next chart to use for isolating a problem.

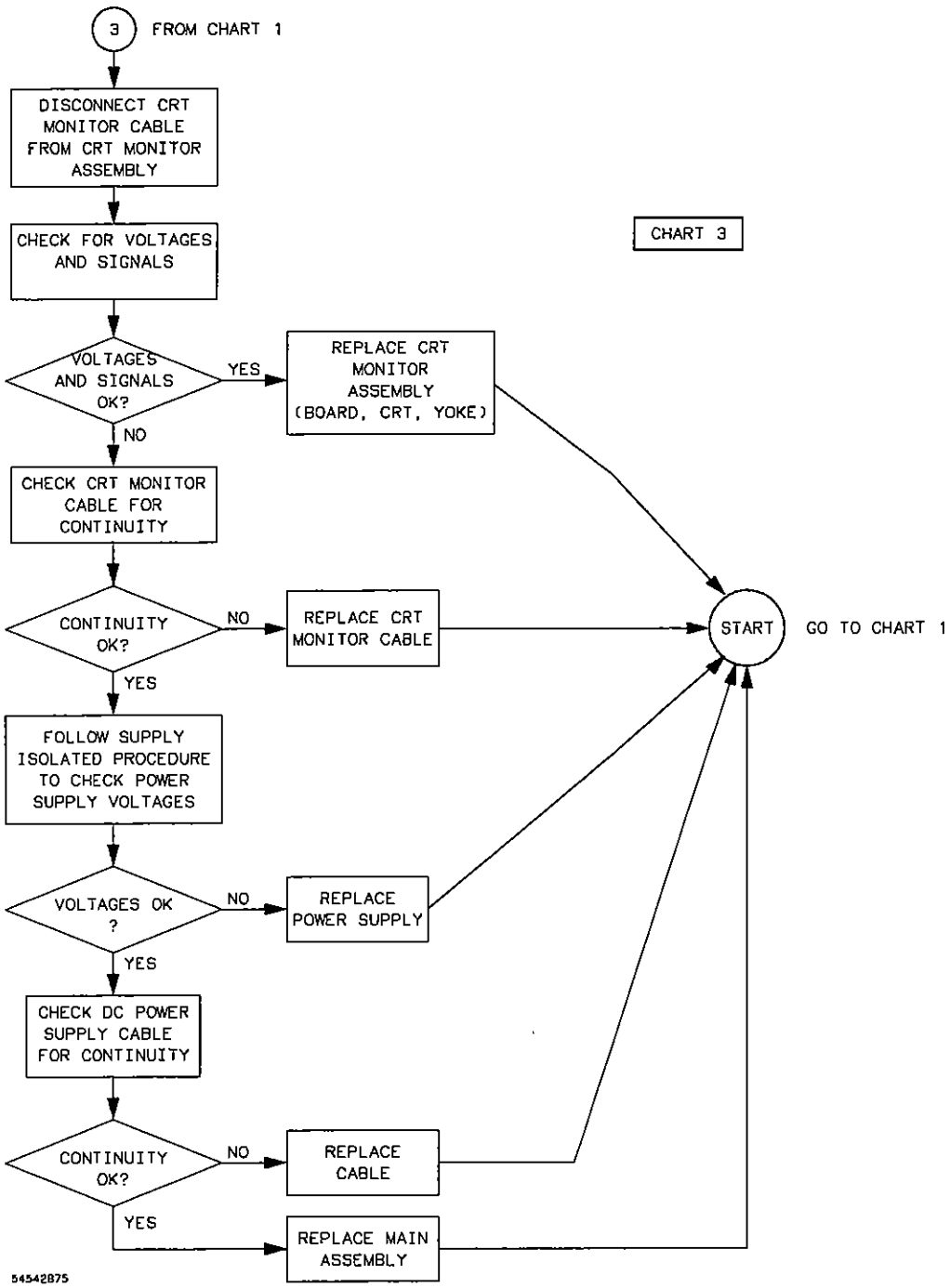
The flowcharts start on the following page.



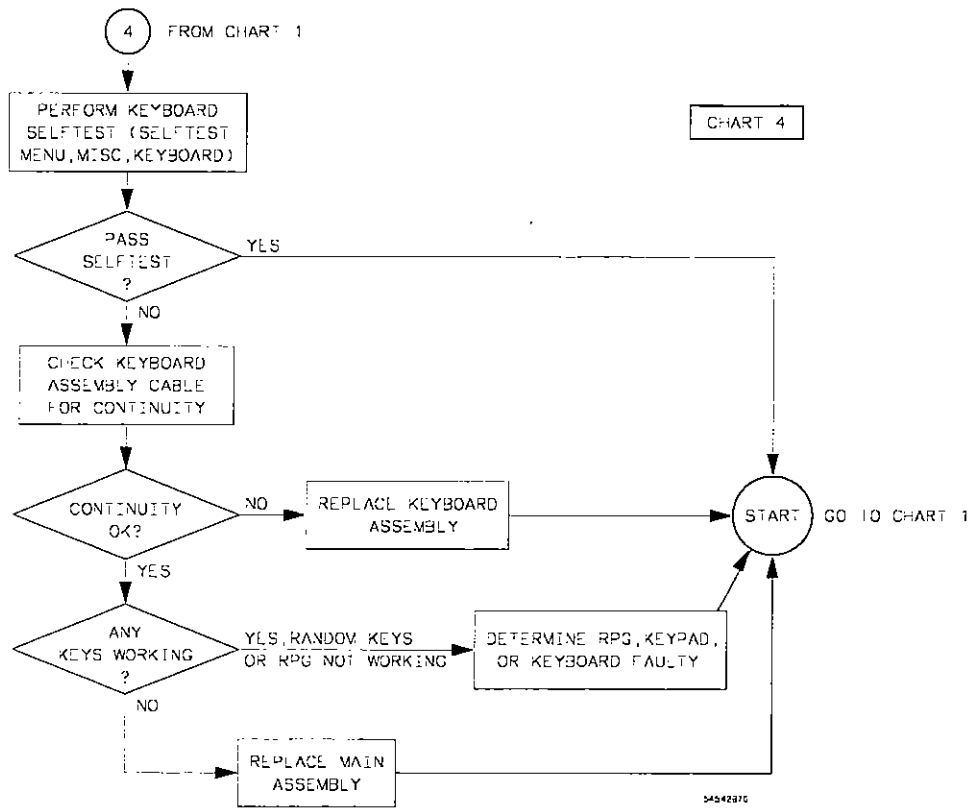
Primary Trouble Isolation Flowchart



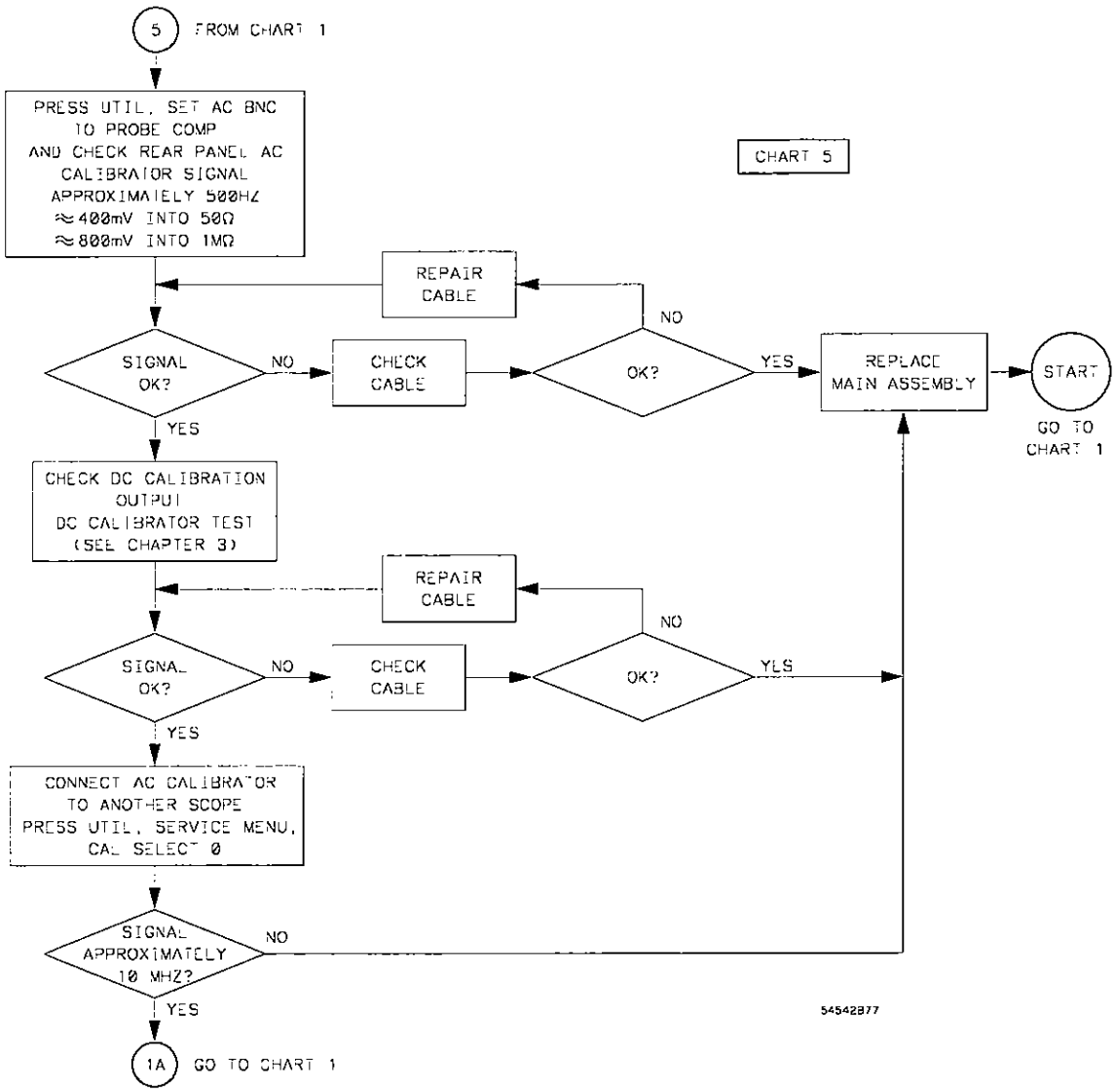
Trouble Isolation Chart for Power Supply



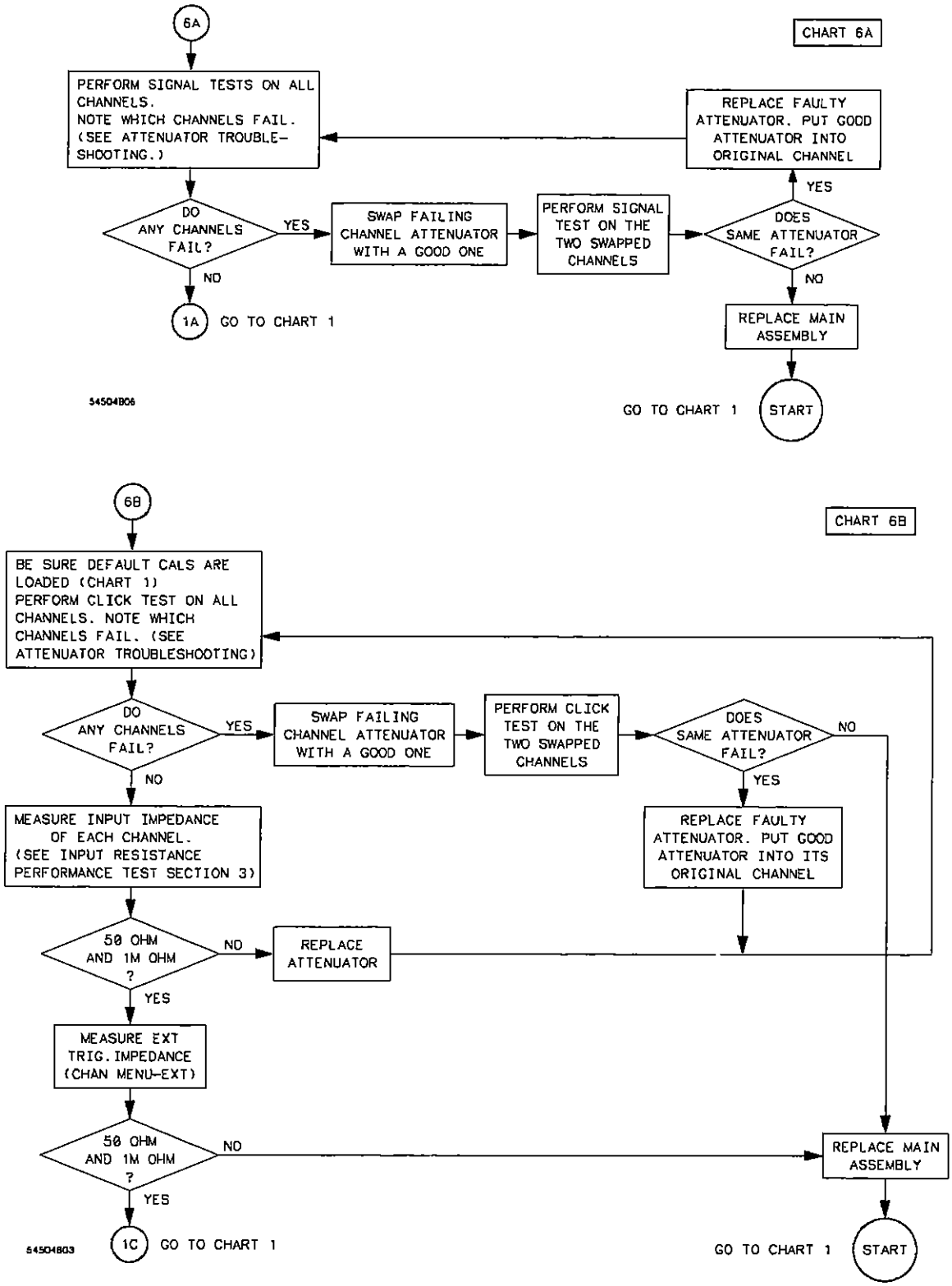
Trouble Isolation Chart for Display



Trouble Isolation Chart for Keyboard



Trouble Isolation Chart for Cal signals



Trouble Isolation Chart for Attenuators

To check power supply voltages

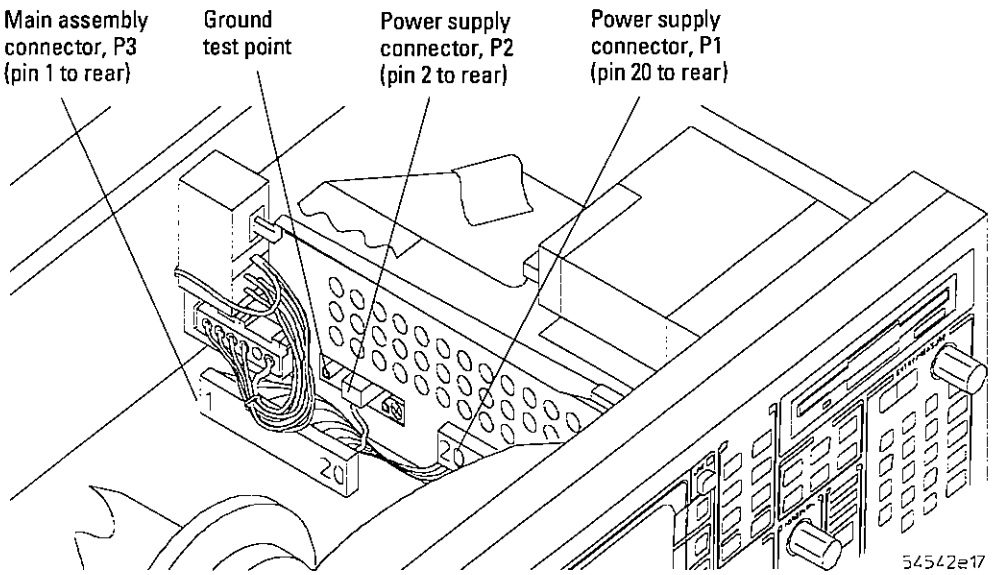
The power supply can be checked loaded or unloaded.

Warning

HAZARDOUS VOLTAGES!
This procedure is to be performed only by service-trained personnel who are aware of the hazards involved (such as fire and electrical shock). Lack of awareness of the hazards could result in electrical shock and death.

Supply Loaded

1 Remove the power cord and cover.
2 Replace the power cord and turn on the instrument.
3 Using the figure below, check for the voltages indicated.



Power Supply Testing Features

Supply Isolated

Isolate and check the supply with the following steps. Use the figure above for reference.

1 Remove the power cable.
2 Disconnect the supply output cable at the supply (see figure above).
3 Load the +5.20 V supply with a 2-ohm, 25-watt resistor. Use jumper wires to connect one end of the resistor to any of pins 1-4, and the other end to any of pins 5-8.

4 Reconnect the mains power cable and check for voltages at the supply output using values in the following table.

Power Supply/Main Assembly Voltages

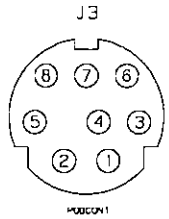
Pin	Supply	Pin	Supply	Pin	Supply	Pin	Supply
Power Supply connector, P1 and Main Assembly connector, P3 - Pins 1-20							
1	+5.20 V	6	Ground	11	-5.2 V	16	Ground
2	+5.20 V	7	Ground	12	Ground	17	+12 V (Disp)
3	+5.20 V	8	Ground	13	+12 V	18	-5.2 V
4	+5.20 V	9	+3.5 V	14	Ground	19	+15.5 V (Fan)
5	Ground (Disp)	10	Ground	15	-12 V	20	Ground (Fan)
Power Supply connector, P2				Main Assembly connector, P3			
1	-5.2 V	2	-5.2 V	21	-5.2 V	22	-5.2 V

To check probe power outputs

The two probe power outputs are on the rear panel.

Use the table and figure to the right to check the power output at the connectors. The +12 V and –12 V supplies come directly from the power supply and the +6 V and –6 V supplies are developed in three- terminal regulators on the main assembly.

Pin	Supply
1	NC
2	NC
3	–6 V
4	–12 V
5	NC
6	+12 V
7	Ground
8	–6 V



To check CRT monitor signals

This test checks for the signals between the main assembly and the CRT Monitor.

1 Remove the top cover.

2 Check the CRT Monitor input cable for the signals and supplies listed in the table below. The cable is the wide ribbon cable connecting the monitor PC board to the main assembly.

3 The video signal is an analog signal from an eight-bit digital-to-analog converter. Check for activity on that line.

CRT Monitor Input Cable Pin Assignments

Pin	Supply/Signal	Pin	Supply/Signal	Pin	Supply/Signal	Pin	Supply/Signal
1	+5 V (Digital)	6	Ground	11	VERT_SYNC	16	Video
2	+12 V (Display)	7	+12 V (Display)	12	+12 V (Display)	17	Ground
3	Ground	8	Ground	13	Ground	18	NC
4	Ground	9	+12 V (Display)	14	Ground	19	Ground
5	+12 V (Display)	10	HOR_SYNC	15	Ground	20	+5 V (Digital)

To check the keyboard

Use the following steps to isolate a faulty elastomeric keypad or keyboard when random keys are not operating.

1 Remove the power cable.

2 Without disconnecting the keyboard cable, use the keyboard removal procedure in chapter 6 to loosen the keyboard. Leave the keyboard in place in the front of the instrument.

3 Replace the power supply.

You can leave the disk drive connected. Just set it to the side, out of the way.

4 Apply power with a key-down powerup.

5 Run the keyboard selftest to determine the failed keys.

a Press `Utility` , then press **`selftest menu`**.

b Select **`misc`** then **`keyboard`**, then press **`start test`**.

c Check the keyboard.

1 Press each key once.

2 Follow the instructions on the screen to check the LEDs.

3 Rotate the RPGs

4 Press Run twice more to exit.

6 Remove the keyboard assembly from the front panel.

CAUTION Be careful not to contaminate the key side of the PC board or the keypads. Dust and fingerprints on these parts may cause intermittent key operation.

7 Separate the PC board from the elastomeric keypad and keyboard panel.

a Remove two screws.

b Slide the plastic keyboard spacer down until the tabs at the top are clear of the keyboard panel.

c Lift the top of the spacer away from the keyboard and slide the spacer out of its bottom mounting.

d Lift the keyboard off of the keyboard panel and keypad.

8 Carefully short the PC board trace (with a paper clip or screwdriver) at the nonoperating key (as determined by keyboard test) and look for an appropriate response on the display.

9 If the display responds as if a key were pressed, replace the elastomeric keypad.

10 If the display does not respond as if a key were pressed, replace the keyboard.

11 Reassemble the instrument.

Troubleshooting attenuator failures

Checking the signal output of the attenuators on the surface-mount PC board is not practical, so the best method for troubleshooting attenuator failures is to swap the suspected one with a known good one. The following discussion will help you determine whether the attenuator or PC board is causing a problem.

The attenuators consist of the following:

- A solenoid selected input resistance
- Two solenoid selected passive attenuators (1:1/5:1 and 1:1/25:1) which can be cascaded to provide attenuation ranges of 1:1, 5:1, 25:1, 125:1
- An FET input circuit
- A programmable preamplifier

Defective attenuators can cause a variety of symptoms.

- Wrong input resistance
- Low bandwidth/slow rise time
- Signal distortion
- Calibration failures
- Self-test failures

The combination of attenuator and PC assembly affects the pulse response. You must check or adjust the pulse response after making any of the following changes.

- After installing a new attenuator. Adjust the channel with the new attenuator.
- After installing a new PC board. Both channels must be adjusted.
- Permanently swapping the attenuators, as when troubleshooting. Adjust the affected channels.

For pulse adjustment, of any affected channels, see "To adjust high-frequency pulse response" in chapter 4, "Calibrating and Adjusting."

Firmware Calibration should also be done after attenuator replacement (see chapter 4, "Calibrating and Adjusting.")

Attenuator Click Test

The solenoids for the passive attenuators can be heard switching when the vertical sensitivity is changed. The fine mode of the RPG will give the most accurate indication of when a solenoid switches. However, the gain calibration will give different switching points to different attenuator assemblies. Individual attenuator assemblies will not necessarily switch at the same sensitivities. Also, there are different sets of calibration factors for certain time/div ranges so the passive attenuator changeover may depend on the sweep speed. They usually switch near the following:

- 45 to 50 mV/div
- 235 to 250 mV/div
- 1.15 to 1.25 V/div

You can hear solenoid switching when going either direction through the transitions.

You can hear the input resistance solenoid when the input resistance is changed (CHAN menu).

Attenuator swapping is the best method of finding a faulty attenuator. Swap suspected and good attenuators, and r-run the tests.

Self-test Menu

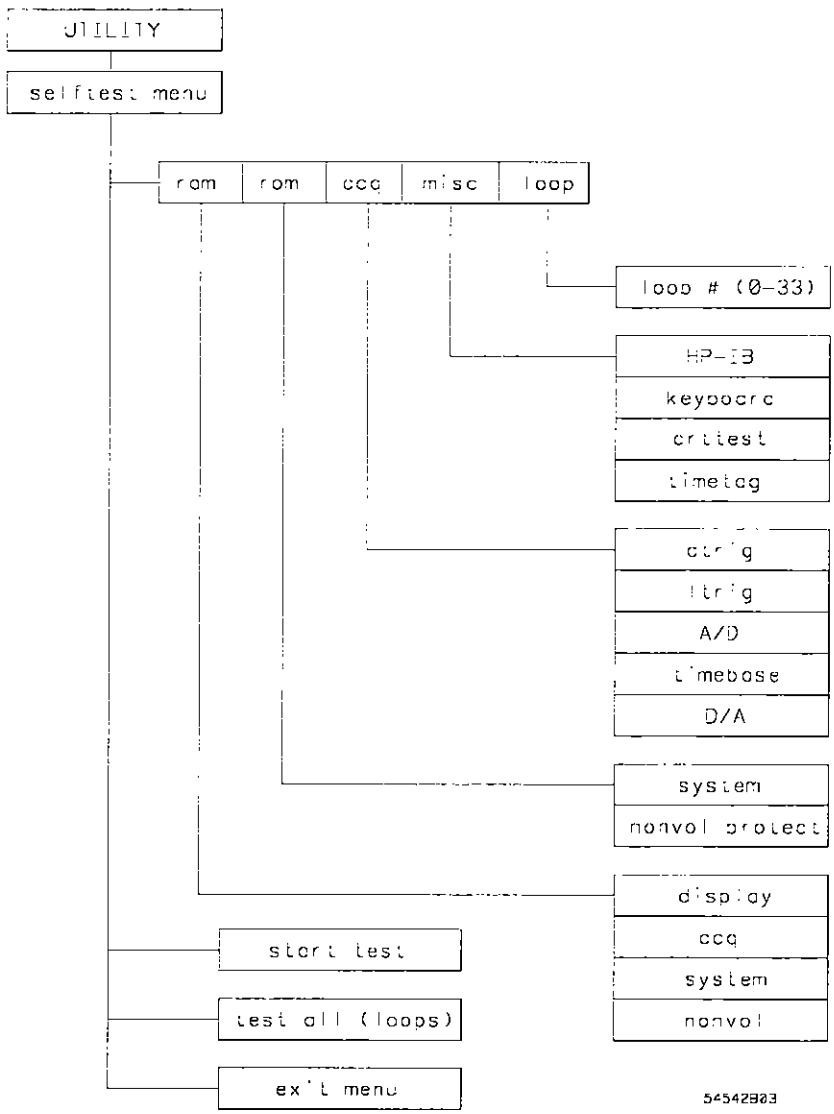
The self-tests are used for isolating problems in the oscilloscope. To avoid any erroneous results, a key-down powerup sets critical parameters to known values. To start the tests:

1 Perform a key-down powerup.

2 Press `Utility` , then press **`selftest menu`**.

The following figure shows the choices in the self-test menu. The tests may be run individually or, by selecting test all, consecutively. The message PASSED or FAILED is displayed after the completion of each test. If there are failure messages for acquisition circuitry, it may help to perform the calibration procedures in chapter 4, "Calibrating and Adjusting." If self-tests continue to fail, the main assembly requires service by HP. This guide does not support component-level troubleshooting.

The loop test in the self-test menu is used for HP service only.



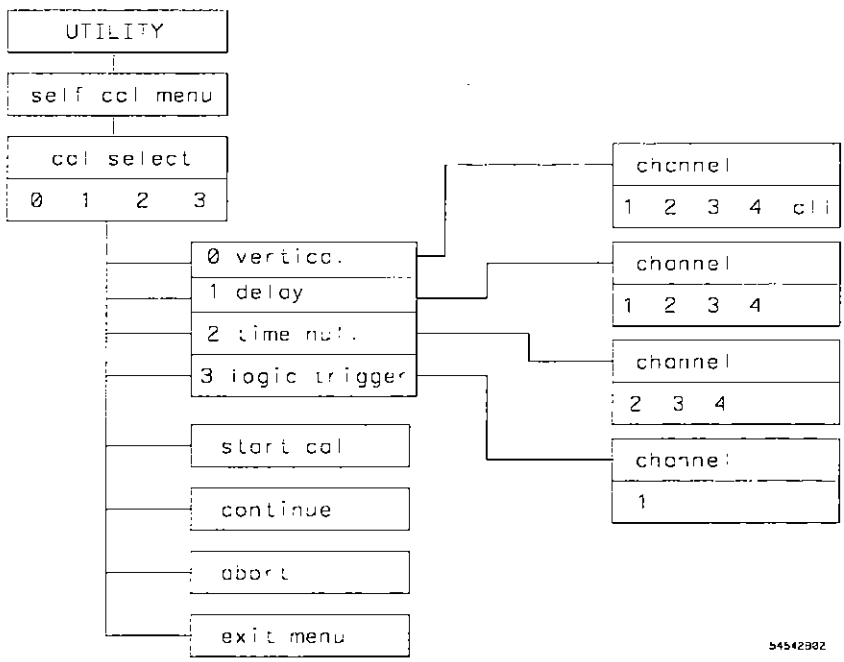
Selftest Menu

Self-Cal Menu

The Self Cal Menu is used to calibrate the instrument. Signals are supplied through the AC cal and DC cal BNCs on the rear panel. The only additional equipment needed are BNC cables and adapters. There are several notable points:

- These PROTECTED SYSTEM CALs are protected by the Calibration switch accessible through the rear panel.
- After a new operating system is loaded into NV-ROM from the disk drive, the calibration factors may be loaded with defaults. The instrument must be calibrated before use.
- Each calibration can have one of four statuses for each channel:
  - P – Passed – Calibration was successful
  - F – Failed – Calibration failed.
  - D – Defaulted – Calibration factors have been loaded with default values.
  - C – Corrupted – Calibration factors have become corrupted. The checksums in the memory do not correspond with the data.
  - * – Indicates that new software or firmware, or both, has been loaded and the function or channel has not been recalibrated.

Specific procedures and instructions for using the self cals is located in chapter 4, "Calibrating and Adjusting."



Self Cal Menu

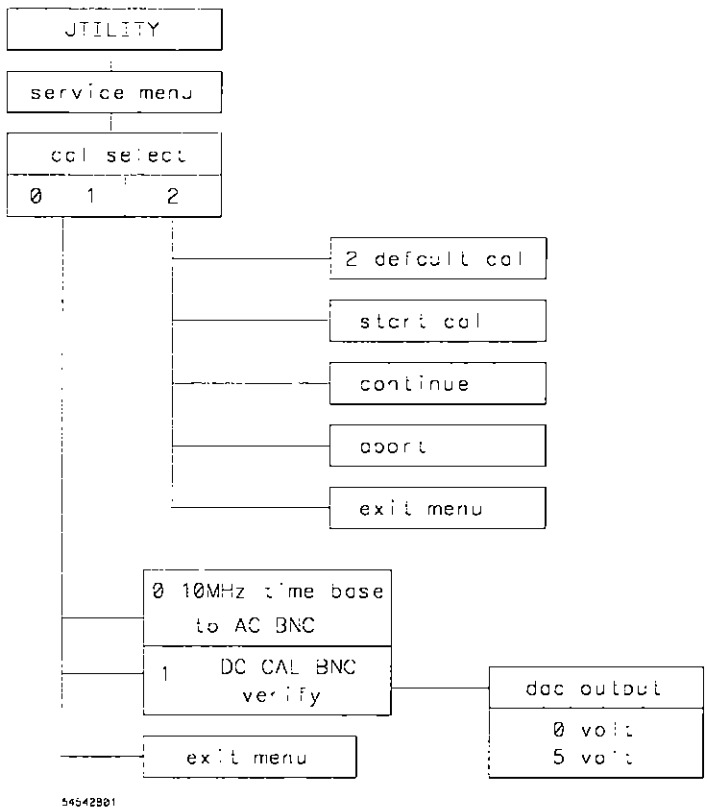
Service Menu

The service menu contains functions that are used only during service procedures. The figure below diagrams the menu. Service menu use is covered in the appropriate procedures.

CAL DAC AND CLOCK VERIFY (cal selects 0, 1) provides two signals to check at the rear panel BNC outputs.

- The **`0. 10MHz timebase to AC BNC`** signal is a 10 MHz signal derived from the 100 MHz sample clock. When selected, it is sent to the AC cal output.
- The **`1. DC CAL BNC verify`** signal represents the limits of the dc calibration signal. Either the 0 V or 5 V reference can be selected and checked at the DC cal output.

PROTECTED SYSTEM CAL DEFAULTS (cal select 2) loads baseline firmware calibration factors, which is necessary before performing self calibration. This function is protected by the Calibration switch on the rear panel.



Service Menu

Software Revisions

A softkey in the Utility menu displays the present configuration of the instrument firmware and software

- Press `Utility` , then press **`software revisions`**. The instrument will display the dates and revision numbers of:
  - BootRom Firmware
  - BootRom Software
  - System Software
  - Keybd Firmware

  This information may be useful when contacting HP for further service information.

Registration Form

In the instrument software is a registration form. This form is your way of communicating directly with the factory. Because the form is stored in memory, you can print a copy whenever you like.

1 Print the form from the oscilloscope:
   a Connect a printer to the oscilloscope using the HP-IB port or the RS-232 serial port, depending on your printer.
   b Press `Utility` . If you are using an HP-IB printer, make sure the HP-IB is set to **`HPIB talk`**.
   c Press **`System menu`**, then press **`registration form (print)`**.

   The instrument will automatically include the configuration information.
2 If a printer is not available, there is a similar version of the form on the next page. Make a copy of the page.
3 Fill out the form, including as much information as you can.

   To display the instrument software information, press `Utility` , then press **`Software revisions`**.
4 Mail (or FAX) the form to the address (or phone number) on the form.

HP 54500 Series Registration Form

Please complete this form and FAX or MAIL it to Hewlett-Packard to ensure that we can contact you when firmware updates or new product information becomes available. Anyone responsible for the maintenance of this product, as well as the end user, should register. Please register even if you are not the original purchaser. This form can also be used to inform us if your address changes. Return the form to:

By Mail:
Hewlett-Packard, Colorado Springs Division
54500 Series Product Marketing Engineer
P.O. Box 2197
Colorado Springs, CO 80901-2197, USA

By FAX
(719) 590-3505

Your Name _____ Job Title _____

Company Name _____ Division _____

Telephone:Area/Country Code_____ Phone Number_____

Street Address_____ FAX Number_____

City_____ Prov/State_____ Mail Stop_____

Postal/Zip Code_____ Country_____ Department_____

How would you prefer to be contacted? _____Mail _____FAX _____Phone

==========Optional Information==========

What are you making measurements on? (check all that apply)

____Computers ____Disk Drive ____Tape Drive ____ICs

____Lasers ____Fiber Optics ____Instrumentation ____Video

____Microprocessors(#_____) ____Datacom ____Telecom

____RF/Microwave Communications ____High-Energy Research ____TV

____Other (please describe)_____

_____

_____

What is the primary application for this product? (check all that apply)

____General troubleshooting ____Computer Aided Test (CAT)

____Digital Design and Debug ____Data Acquisition (computer aided)

____Analog Design Verification ____Go/No Go measure limit tests

____Device Characterization/Test ____Go/No Go waveform compare tests

____Transient waveform capture ____Other (please describe)

_____

_____

Comments about this product?_____

_____

_____

Current Date/Time:_____

Model:_____

Serial Number:_____

Software Revision:_____

6

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Tools Required 6-2
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Replacing Assemblies

Replacing Assemblies

Procedures in this chapter should be used when removing and replacing assemblies and parts in the HP 54520 and 54540 series oscilloscopes.

In general, the procedures that follow have been placed in the order they must be used to remove a particular assembly. That is, given first are the procedures for assemblies that must be removed first.

ESD Precautions

When using any of the procedures in this chapter you should use proper ESD precautions. As a minimum you should place the instrument on a properly grounded ESD mat and wear a properly grounded ESD wrist strap.

Tools Required

The following tools are required for these procedures.

- Torx drivers: T10, T15
- Socket wrench: 5/8 inch
- Medium size (3/16-in) flat-blade screwdriver
- Nut Drivers: 3/16-in, 9/32-in, 5/16-in, 5/8-in
- Torque driver, 0.34 Nm (3 in-lbs), 5 mm or 3/16-in hex drive
- Torque driver, 0.23 Nm (2 in-lbs), Torx T6 drive

CAUTION

Do not remove or replace any circuit board assemblies in this instrument while power is applied. The assemblies contain components which may be damaged if the assembly is removed or replaced while the instrument is powered.

WARNING

SHOCK HAZARD!
To avoid electrical shock, adhere closely to the following procedures. Also, after disconnecting the power cable, wait at least three minutes for the capacitors on the power supply and sweep boards to discharge before servicing this instrument. Hazardous voltages that can cause death exist on the power supply, CRT, and the display sweep board.

To return the instrument to HP for service

Before shipping the instrument to Hewlett-Packard, contact your nearest HP sales office for additional details.

1 Write the following information on a tag and attach it to the instrument.

- Name and address of owner
- Instrument model numbers
- Instrument serial numbers
- Description of the service required or failure indications

2 Remove all accessories from the instrument.

Accessories include all cables. Do not include accessories unless they are associated with the failure symptoms.

3 Protect the instrument by wrapping it in plastic or heavy paper.

4 Pack the instrument in foam or other shock absorbing material and place it in a strong shipping container.

You can use the original shipping materials or order materials from an HP sales office. If neither is available, place 8 to 10 cm (3 to 4 inches) of shock-absorbing material around the instrument and place it in a box that does not allow movement during shipping.

5 Seal the shipping container securely.

6 Mark the shipping container as FRAGILE.

In any correspondence, refer to instrument by model number and full serial number.

To remove and replace the cover

Use the following steps to remove and replace the cover.

1 Disconnect the power cable.

2 Remove eight flathead screws that secure the trim strip.

- Four on the top
- One at each side
- Two on the bottom near the center

3 Remove the two screws that secure the handle.

4 Remove the screws and washers that secure the four rear feet.

5 Slide the instrument out through the front of the cover.

6 To reassemble the instrument, reverse the procedure.

To remove and replace the rear panel

Use the following steps to remove and replace the rear panel assembly.

1 Disconnect the power cable.

2 Remove the cover.

3 Detach the power switch extension shaft from the power switch at the line filter.

The jaws of the extension shaft have ridges that fit into notches on each side of the switch shaft. Both ridges must clear the notches before the extension shaft can be removed.

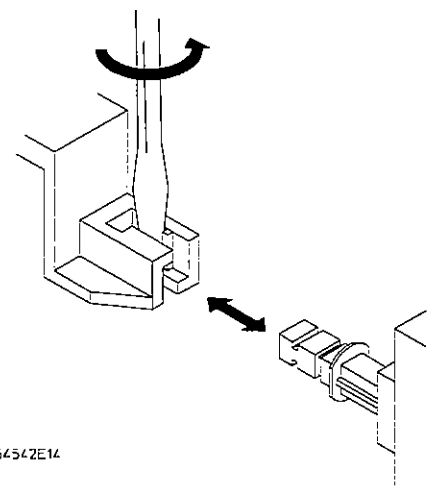
a Use a medium-size flat-blade screwdriver (about 1/4 inch or 6 mm) to carefully spread the jaws of the switch extension shaft.

b While spreading the jaws, pull the extension shaft toward the front of the instrument.

c When the extension clears the switch, remove the extension from the front panel.

d To install the shaft, reverse the procedure.

You must spread the jaws of the extension shaft to install it on the switch shaft.



4 Detach the line filter cable from the power supply.

5 Remove the six pan-head screws at the edges of the rear panel.

6 Pull the rear panel straight away from the instrument about three inches. Note the banana connector at the bottom-right corner of the rear panel. During reassembly, be sure it inserts into the clip on the main assembly.

7 Disconnect all of the various cables from the main assembly. For reassembly, note which coaxial cable goes to which connector on the main assembly.
   - Line sync (Connects the line sync transformer on the line filter cable to the PC board.)
   - HP-IB
   - RS-232
   - Coaxial cables
8 Separate the rear panel from the cabinet.
9 Replace the rear panel by reversing this procedure.

To remove and replace the disk drive

Use this procedure to remove and replace the disk drive. When necessary, refer to other removal procedures.

1 Disconnect the power cable.
2 Remove the cover.
3 Remove two screws that secure the disk drive and bracket to the top of the power supply.
4 Slide the disk drive back and out of the instrument.
5 Disconnect the ribbon cable at the disk drive.
6 Remove four screws that secure the bracket to the disk drive.
7 To reassemble the instrument, reverse the procedure.

To remove and replace the power supply

Use the following steps to remove the power supply assembly. When necessary, refer to other removal procedures.

1 Disconnect the power cable.
2 Remove the cover.
3 Remove two screws that attach the disk drive and bracket to the top of the supply.
   You can leave the disk drive attached by its cable.
4 At the power supply, disconnect the cable that connects the supply to the main assembly.
   The cable has two connectors at the supply.
5 Disconnect the line filter cable at the power supply.
6 Remove the two locking pins that secure the power supply at the right front and rear corners of the cabinet. Pull the pins up and out.
7 Slide the supply out through the side of the cabinet.
8 To replace the supply, reverse this procedure.

To remove and replace the keyboard

Use the following procedure to remove and replace the keyboard assembly. When necessary, refer to other removal procedures.

1 Disconnect the power cable.

2 Remove the cover.

3 Remove the power supply.

> **Keyboard cable routing**
> Before going further, note the routing of the keyboard cable. It should be routed next to the front panel to just under the CRT, then directly routed to the rear of the instrument where it connects to the main assembly. It should be kept close to the main assembly for its entire length. Avoid routing the cable between the power supply and the acquisition circuitry on the main assembly.

4 From the back side of the front panel, remove the four screws that secure the keyboard assembly to front of the cabinet.

5 Use the following steps to disassemble the keyboard assembly.

- **a** Remove the knobs. They have a friction fit on the shafts.
- **b** Remove two screws that secure the keyboard spacer to the assembly.
- **c** Slide the keyboard spacer down until the tabs at the top are clear of the keyboard panel.
- **d** Lift the top of the spacer away from the keyboard and slide the spacer out of its bottom mounting.
- **e** Lift the keyboard off of the keyboard panel and keypad.
- **f** The Keyboard label uses self-stick adhesive. If it must be removed, peel it off.
- **g** If it is necessary to replace the PC board, disconnect the keyboard cable at the keyboard.

6 Replace keyboard assembly by reversing this procedure. Be sure the keyboard cable is routed properly when reassembling the instrument. (See "Keyboard Cable Routing" above.)

To remove and replace the fan

Use the following procedure to remove and replace the fan. When necessary, refer to other removal procedures.

1 Loosen the rear panel by following steps 1 through 6 of the rear panel procedure.

2 For reassembly, note orientation of the fan cable.

3 Remove the fan by removing the four screws securing it and the fan guard to the rear panel.

CAUTION When replacing the fan, be sure air flow at the fan is from outside into the instrument. Check the flow arrows on the fan and check for proper flow once power is applied to the instrument. Improper air flow can cause overheating of parts of the instrument.

4 To install the fan, reverse this procedure.

To remove and replace rear panel cables

Rear panel cables are connected to the main assembly at the rear of the instrument.

1 Loosen the rear panel by following steps 1 through 6 of the rear panel procedure.

2 Disconnect the desired cable from the main assembly.

3 Remove the desired cable from the rear panel.

4 To reassemble the instrument, reverse the procedure.

To remove and replace the main assembly

Use the following procedure to remove and replace the main assembly. When necessary, refer to other removal procedures.

CAUTION

ELECTROSTATIC DISCHARGE!
Use grounded wrist straps and mats when servicing the main assembly. Electrostatic discharge can damage electronic components.

- If you are replacing the main assembly with an exchange assembly, you will have to move the attenuators to the replacement assembly. Attenuators are not part of the main assembly.
- If you are installing a new main assembly, the replacement assembly includes attenuators.

1 Disconnect the power cable.
2 Remove the cover.
3 Remove the following in order.
   - Rear panel
   - Disk drive
   - Power supply
4 Disconnect the following cables from the main assembly.
   - Disk drive cable
   - Power supply cable
   - Line sync cable
   - Display cable
   - Keyboard cable
   - Front panel probe compensation cable
5 Carefully place the instrument on its side.
6 From the bottom of the instrument, remove eight screws that secure the main assembly to the cabinet.
7 Remove the nuts that hold the BNCs to the front panel.
8 Set the instrument in the normal position.
9 Slide the main assembly out of the cabinet to the rear.
10 Replace the main assembly by reversing this procedure.

If you permanently replace parts
If you have permanently changed any combination of main assembly, attenuator, or acquisition hybrid, you will need to adjust the high-frequency pulse response on the affected channels. For example:
If you permanently swap two attenuators or acquisition hybrids during troubleshooting, you must adjust the channels affected.
If you replace one attenuator or hybrid, you must adjust that channel.
If you replace the main assembly, you must adjust all channels.

To remove and replace an attenuator

Use the following procedure to remove and replace an attenuator assembly. When necessary, refer to other removal procedures.

CAUTION

ELECTROSTATIC DISCHARGE!
Use grounded wrist straps and mats when servicing the main assembly. Electrostatic discharge can damage electronic components.

Attenuators are not part of the main assembly. If the Main assembly is replaced, the attenuators will have to be moved to the replacement assembly.

1 Remove the main assembly.

2 From the bottom of the main assembly, remove two screws that secure the attenuator.

3 A 24-pin connector, located at the rear of and inside the attenuator, connects it to the PC board. With a gentle rocking or prying motion, lift the attenuator from the PC board.

Use a small flat-blade screwdriver, prying at the rear between the attenuator and PC board, to help control attenuator removal.

4 Reassemble the instrument by following the appropriate steps of all procedures.

If you permanently replace parts
If you have permanently changed any combination of main assembly, attenuator, or acquisition hybrid, you will need to adjust the high-frequency pulse response on the affected channels. For example:

- If you permanently swap two attenuators or acquisition hybrids during troubleshooting, you must adjust the channels affected.
- If you replace one attenuator or hybrid, you must adjust that channel
- If you replace the main assembly, you must adjust all channels.

To remove and replace an acquisition hybrid

Use the following procedure to remove and replace an acquisition hybrid. When necessary, refer to other removal procedures.

CAUTION

ELECTROSTATIC DISCHARGE!
Use grounded wrist straps and mats when servicing the main assembly. Electrostatic discharge can damage electronic components.

You do not have to remove the main assembly before replacing an acquisition hybrid.

To understand the sequence of parts, use the accompanying illustration.

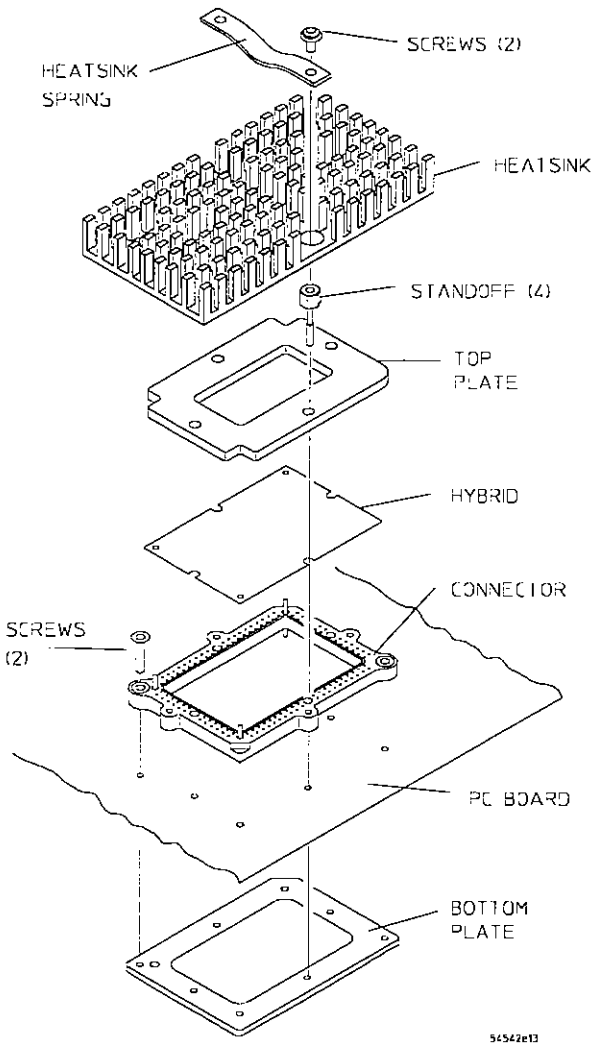
To Remove

1 Remove the cover and power supply.

2 Use a T-6 Torx driver to remove two screws that secure the heatsink spring, then remove the heatsink.

3 Use a 3/16 hex driver to remove four standoffs that secure the top plate.

4 Lift the hybrid off of the connector assembly.



To Replace

The location of pins and other locator features will guide the alignment of parts. This assembly cannot be assembled incorrectly without forcing.

1 Install the hybrid with the three corner holes over the three large locator pins.

2 Install the top plate with the three cut-out corners over the three locator pins.

CAUTION

Tighten the hybrid carefully. Excess force or improper procedure may break the hybrid, which is very expensive to replace.

3 Loosely install the four hex standoffs.

4 Use a 5 mm (3/16 in) torque driver set to 0.34 Nm (3 in-lbs) to tighten the standoffs in the following sequence.

a Tighten any standoff to specifications.

b Tighten the standoff directly opposite the first one to specifications.

c Tighten the remaining two standoffs to specifications.

5 Check for the graphite pad on the underside of the heatsink, then install it with the hole that is near one corner toward the front of the instrument.

When the heatsink is installed properly, you will be able to see the adjustment potentiometer through the hole in the heatsink.

6 Install the heatsink spring with the curve down.

7 Install the two heatsink screws . Use a T6 torque driver set to 0.23 Nm (2 in-lbs) to tighten them.

If you permanently replace parts

If you have permanently changed any combination of main assembly, attenuator, or acquisition hybrid, you will need to adjust the high-frequency pulse response on the affected channels. For example:

If you permanently swap two attenuators or acquisition hybrids during troubleshooting, you must adjust the channels affected.

If you replace one attenuator or hybrid, you must adjust that channel

If you replace the main assembly, you must adjust all channels.

The Hybrid Connector

As can be seen in the illustration on the previous page, two screws through the hybrid connector hold the bottom plate to the underside of the PC board. If the connector is removed, the bottom plate is able to fall away from the board.

Sometimes the plate will stick to the bottom of the board by itself because of adhesives that fasten an insulator to the plate. If the connector is very gently removed and replaced, you may be able to replace the connector without removing the main assembly. The key is to apply very little pressure while removing the connector screws. Too much pressure will push the plate away from the bottom of the board. If the plate falls from the board, you will have to remove the main assembly to reinstall the connector. If the plate does not fall from the board, you will have saved some time and work.

To replace a connector:

1 Remove the main assembly from the instrument.

2 Follow the procedure above to remove the hybrid.

3 Remove the two screws to remove the connector.

4 Reassemble by following all procedures, taking note of the following:

- Use a T6 torque driver set to 0.23 Nm (2 in-lbs) to tighten the hybrid connector screws.

To remove and replace the CRT monitor assembly

The sweep board, CRT, and CRT yoke are all parts of one HP part number. They have been adjusted as a unit and should be replaced as a unit, rather than individually. Do not remove the yoke from the CRT. When necessary, refer to other removal procedures.

1 Remove the following assemblies:

- Rear panel
- Power supply
- Main assembly

CAUTION Discharge the post accelerator lead to the CRT mounting band only. Components will be damaged if the post accelerator is discharged to other areas.

2 Discharge the CRT.

a Connect a jumper lead between the CRT mounting band CRT and a screwdriver shaft.

b Discharge the CRT.

Place the grounded screwdriver under the rubber cap of the post-accelerator lead and momentarily touch the screwdriver to the metal clip of the lead.

CAUTION Always discharge the CRT before handling. The CRT may charge up by itself even while disconnected. To keep it from charging, use a jumper to short the CRT post-accelerator terminal to the CRT mounting band. Failure to discharge the CRT can result in electrical shock.

3 Disconnect the post-accelerator lead from the CRT by firmly squeezing the rubber cap until the metal clip disengages from the CRT.

4 Detach the following cables at the sweep board or CRT.

- Intensity cable
- Monitor sweep drive ribbon cable
- CRT yoke cable and base cable

5 Slide the sweep board up and out of the cabinet slot.

When installing the sweep board, it may be necessary to press on the center of the outer shield of the sweep board to allow the board to clear the cabinet support rib.

6 Carefully place the instrument in the front-panel-down position.

7 Remove the three nuts that secure the CRT to the front panel.

8 Remove the washer on the stud at the center of the instrument.

9 Remove the sweep board ground bracket.

10 Remove the pan-head screw that secures the CRT to the front panel.

11 Remove the CRT.

Reinstall the CRT with the post-accelerator terminal toward the middle of the instrument.

12 To install the CRT monitor assembly, reverse this procedure.

After replacing the CRT monitor assembly, and only if necessary, perform the CRT monitor assembly adjustment procedures in chapter 4, "Calibrating and Adjusting."

7 Replaceable Parts

7

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Unlisted Parts 7-2
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Exchange Assemblies 7-2
Power Cables and Plug Configurations 7-3
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Replaceable Parts List 7-6

Replaceable Parts

Replaceable Parts

This chapter of the Hewlett-Packard 54520 and 54540 series oscilloscope service guide includes information for ordering parts. Service support for this instrument is replacement of parts to the assembly level. The replaceable parts include assemblies and chassis parts.

Ordering Replaceable Parts

Listed Parts

To order a part in the parts list, quote the HP part number, indicate the quantity desired, and address the order to the nearest HP Sales Office.

Unlisted Parts

To order a part not listed in the parts list, include the instrument part number, instrument serial number, a description of the part (including its function), and the number of parts required. Address the order to the nearest HP Sales Office.

Direct Mail Order System

Within the USA, Hewlett-Packard can supply parts through a direct mail order system. There are several advantages to this system:

- Direct ordering and shipping from the HP parts center in California, USA.
- No maximum or minimum on any mail order. (There is a minimum amount for parts ordered through a local HP sales office when the orders require billing and invoicing.)
- Prepaid transportation. (There is a small handling charge for each order.)
- No invoices.

In order for Hewlett-Packard to provide these advantages, please send a check or money order with each order.

Mail order forms and specific ordering information are available through your local HP sales office. Addresses and telephone numbers are located in a separate document shipped with the manuals.

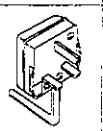
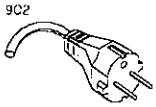
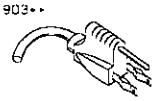
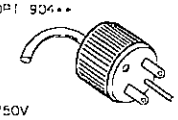
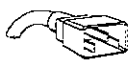
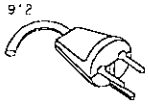
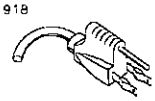
Exchange Assemblies

Some parts used in this instrument have been set up for an exchange program. This program allows the customer to exchange a faulty assembly with one that has been repaired, calibrated, and performance-verified by the factory. The cost is significantly less than that of a new part. The exchange parts have a part number in the form XXXXX-695XX.

After receiving the repaired exchange part from Hewlett-Packard, a United States customer has 30 days to return the faulty assembly. For orders not originating in the United States, contact the local HP service organization. If the faulty assembly is not returned within the warranty time limit, the customer will be charged an additional amount. The additional amount will be the difference in price between a new assembly and that of an exchange assembly.

Power Cables and Plug Configurations

This instrument is equipped with a three-wire power cable. The type of power cable plug shipped with the instrument depends on the country of destination. The following figure shows option numbers of available power cables and plug configurations.

PLUG TYPE	CABLE PART NO.	PLUG DESCRIPTION	LENGTH IN/CM	COLOR	COUNTRY
OPT 900  250V	8120-1351 8120-1703	Straight *BS1363A 90°	90/228 90/228	Gray Mint Gray	United Kingdom, Cyprus, Nigeria, Zimbabwe, Singapore
OPT 901 250V	8120-1369 8120-0696	Straight *NZSS198/ASC 90°	79/200 87/221	Gray Mint Gray	Australia New Zealand
OPT 902  250V	8120-1689 8120-1692 8120-2857	Straight *CEE7-Y11 90° Straight (Shielded)	79/200 79/200 79/200	Mint Gray Mint Gray Coco Brown	East and West Europe, Saudi Arabia, So. Africa, India (Unpolarized in many nations)
OPT 903**  125V	8120-1378 8120-1521 8120-1992	Straight *NEMA5-15P 90° Straight (Medical) UL544	90/228 90/228 96/244	Jade Gray Jade Gray Black	United States, Canada, Mexico, Philippines, Taiwan
OPT 904**  250V	8120-0698	Straight *NEMA6-15P	90/228	Black	United States, Canada
OPT 905  250V	8120-1396 8120-1625	CEE22-V1 (System Cabinet Use) 250V	30/76 96/244	Jade Gray	For interconnecting system components and peripherals United States and Canada only
OPT 906 250V	8120 2104 8120-2296	Straight *SEV1011 1959-24507 Type 12 90°	79/200 79/200	Mint Gray Mint Gray	Switzerland
OPT 912  220V	8120-2956 8120-2957	Straight *DHCK107 90°	79/200 79/200	Mint Gray Mint Gray	Denmark
OPT 917 250V	8120-4211 8120-4600	Straight SABS164 90°	79/200 79/200	Jade Gray	Republic of South Africa India
OPT 918  100V	8120-4753 8120-4754	Straight MITI 90°	90/230 90/230	Dark Gray	Japan

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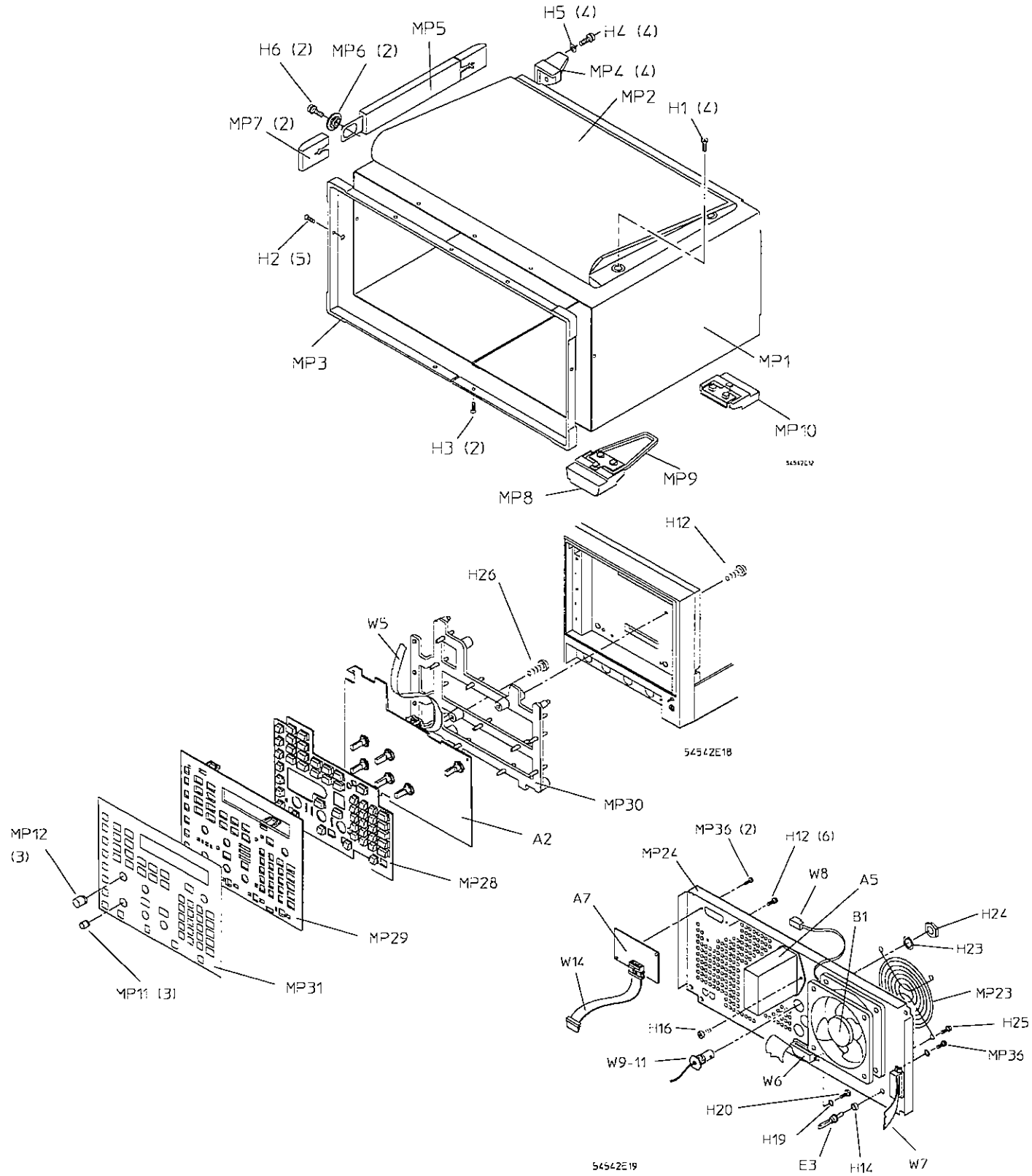
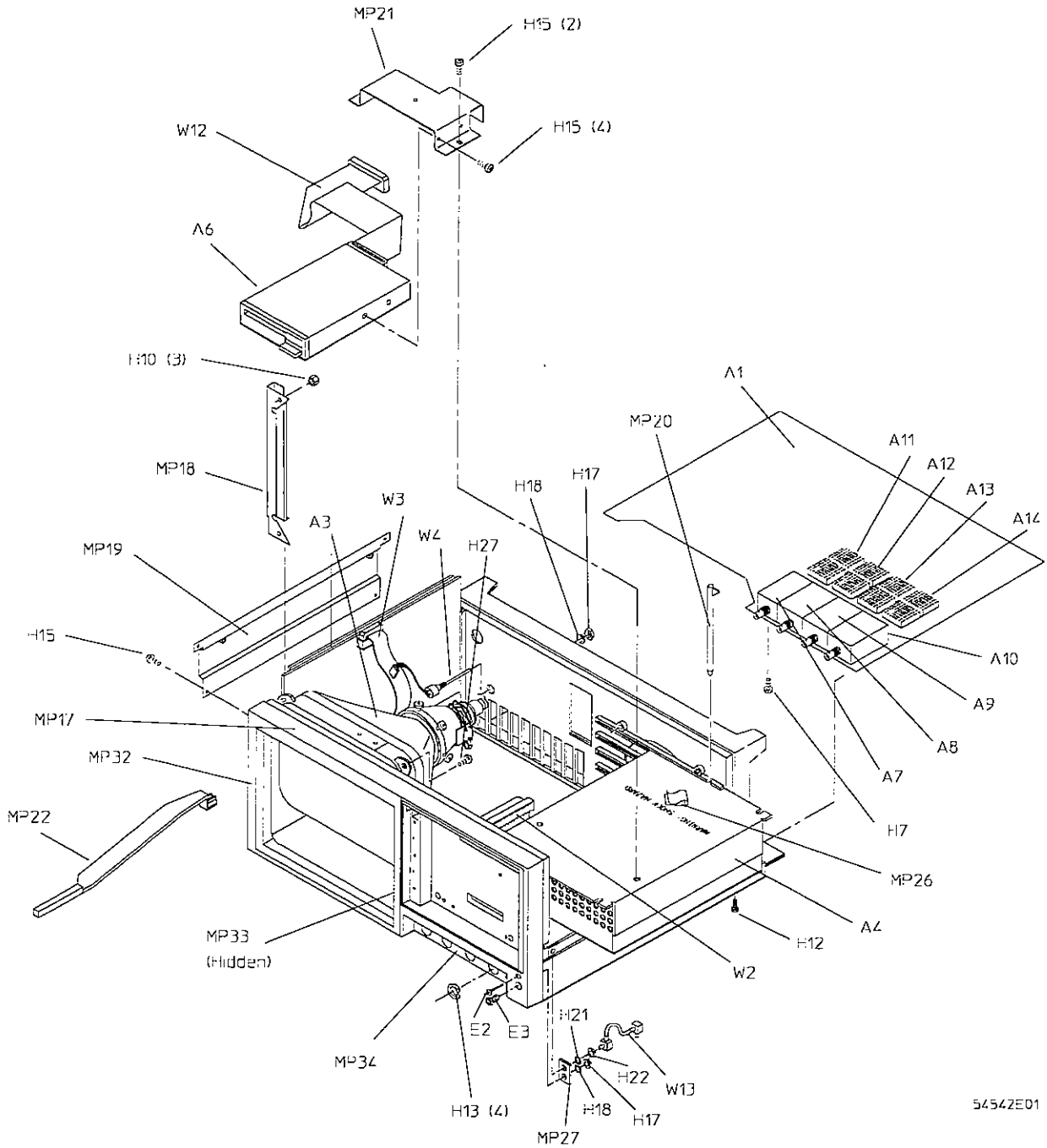
*Part number shown for plug is industry identifier for plug only. Number shown for cable is HP part number for complete cable including plug.

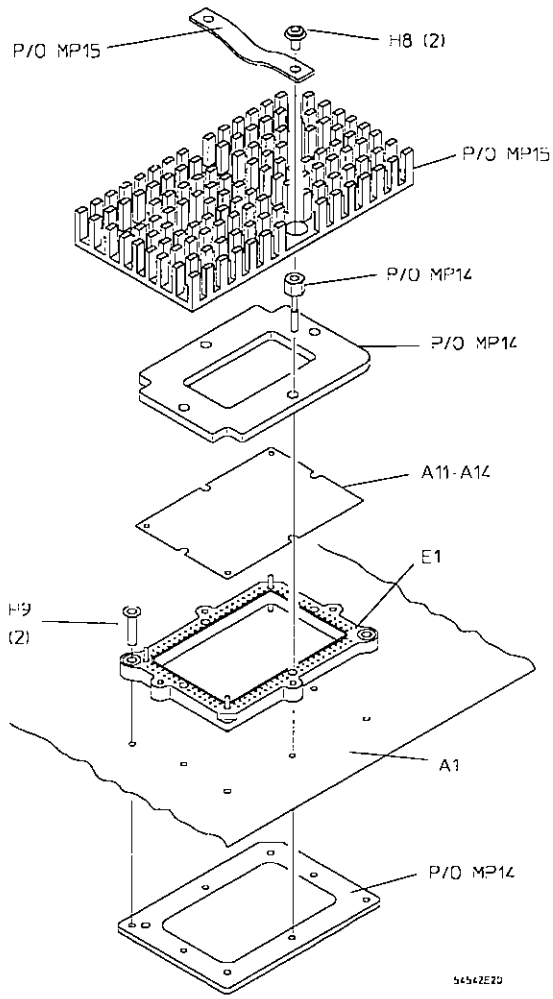
**These cords are included in the CSA certification approval of the equipment.

E=Earth Ground
L=Line
N=Neutral

Exploded Views




MP21
H15 (2)
W12
H15 (4)
A6
H10 (3)
MP18
A1
MP20
A11
A12
A13
A14
H18
H17
W3
A3
W4
H27
MP19
H15
A10
A9
MP17
A8
MP32
A7
MP22
H7
MP26
A4
MP33
(Hidden)
H12
W2
E2
E3
H21
MP34
H22
W13
H13 (4)
H18
H17
MP27
54542E01



Replaceable Parts List

The following table is a list of replaceable parts and is organized as follows:

- Exchange assemblies in alphanumeric order by reference designation.
- External chassis parts in alphanumeric order by reference designation. These parts are generally those that take the physical wear and tear of use.
- Internal parts in several categories. Each category is in alphanumeric order by reference designation. Replacing these parts generally requires opening the cabinet.

The information given for each part consists of the following:

- Reference designation.
- HP part number.
- Total quantity (QTY) in instrument or on assembly. The total quantity is given once and at the first appearance of the part number in the list.
- Description of the part.

Replaceable Parts

Ref. Des.	HP Part Number	QTY	Description
EXCHANGE ASSEMBLIES			
A1	54520-69509		MAIN ASSEMBLY-54520A (without attenuators - with hybrids)
A1	54522-69509		MAIN ASSEMBLY-54522A (without attenuators - with hybrids)
A1	54540-69509		MAIN ASSEMBLY-54540A (without attenuators - with hybrids)
A1	54542-69509		MAIN ASSEMBLY-54542A (without attenuators - with hybrids)
EXTERNAL CHASSIS PARTS			
F1	2110-0055	1	FUSE (4 A, 250 V)
H1	0515-1031	4	MS M3 X 0.50 6MM-LG T10 FLAT-HD (accessory pouch)
H2	0515-2349	5	MS M3 X 0.50 - 14MM-LG T10 FLAT-HD (trim strip, top and sides)
H3	0515-1103	2	MS M3 X 0.50 10MM-LG T10 FLAT-HD (trim strip, bottom)
H4	0515-0664	4	MS M3 X 0.50 12MM-LG T10 PAN-HD (rear feet)
H5	3050-0010	4	WFL 0.147 0.312 0.03 (rear feet)
H6	0515-0382	3	MS M4 X 0.7 12MM-LG T15 PAN-HD (handle)
MP1	01660-04102	1	COVER ASSEMBLY
MP2	5041-9453	1	ACCESSORY POUCH
MP3	01660-40502	1	TRIM STRIP
MP4	01660-40501	4	REAR FOOT (rear panel)
MP5	54542-44901	1	HANDLE - MOLDED VINYL GRIP
MP6	35672-21703	2	STRAP RETAINER
MP7	35672-45004	2	HANDLE END CAP
MP8	5041-8801	2	FRONT FOOT (bottom)
MP9	1460-1345	2	TILT STAND
MP10	5041-8822	2	NON-SKID FOOT (bottom)
MP11	54601-47401	3	KNOB 11.5 MM
MP12	54601-47402	3	KNOB 15.5 MM
MP13			NOT ASSIGNED
W1	8120-1521	1	CABLE-POWER (standard 125V USA)
W1	8120-1703		CABLE-POWER (Option 900-UK)
W1	8120-0696		CABLE-POWER (Option 901-AUSTL)
W1	8120-1692		CABLE-POWER (Option 902-EUR)
W1	8120-0698		CABLE-POWER (Option 904-250V USA/CANADA)
W1	8120-2296		CABLE-POWER (Option 906-SWIT)
W1	8120-2957		CABLE-POWER (Option 912-DEN)
W1	8120-4600		CABLE-POWER (Option 917-AFRICA)
W1	8120-4754		CABLE-POWER (Option 918-JAPAN)

Replaceable Parts (cont'd)

Ref. Des.	HP Part Number	QTY	Description
ELECTRICAL ASSEMBLIES			
A1	54520-66509	1	MAIN ASSEMBLY-54520A (with attenuators and hybrids)
A1	54522-66509	1	MAIN ASSEMBLY-54522A (with attenuators and hybrids)
A1	54540-66509	1	MAIN ASSEMBLY-54540A (with attenuators and hybrids)
A1	54542-66509	1	MAIN ASSEMBLY-54542A (with attenuators and hybrids)
A2	54542-66506	1	BOARD ASSEMBLY - KEYBOARD
A3	2090-0324	1	MONITOR ASSEMBLY
A4	0950-2369	1	POWER SUPPLY
A5	54512-62702	1	LINE FILTER/CABLE ASSEMBLY
A6	0950-2169	1	DISK DRIVE
A7	54542-66508	1	CENTRONICS ASSEMBLY
ATTENUATOR ASSEMBLIES AND PARTS			
A7	54512-63402	4	ATTENUATOR ASSEMBLY (CH 1)
A8	54512-63402		ATTENUATOR ASSEMBLY (CH 2)
A9	54512-63402		ATTENUATOR ASSEMBLY (CH 3, not used on 54520 and 54522)
A10	54512-63402		ATTENUATOR ASSEMBLY (CH 4/external trigger)
H7	0515-0655	8	MS M3 X 0.50 8MM-LG T10 PAN-HD
HYBRID ASSEMBLIES AND PARTS			
A11	1NB7-8353	4	HYBRID - ACQUISITION (CH1)
A12	1NB7-8353		HYBRID - ACQUISITION (CH2)
A13	1NB7-8353		HYBRID - ACQUISITION (CH3, not used on 54520 and 54522)
A14	1NB7-8353		HYBRID - ACQUISITION (CH4, not used on 54520 and 54522)
E1	54542-67601	4	CONNECTOR ASSEMBLY - HYBRID MOUNT (2 used on 54520 and 54522)
H8	0515-0365	8	MS M2 X 0.4 4MM-LG T6 PAN-HD
H9	0515-2363	8	MS M2 X 0.4 8MM-LG T6 FLAT-HD
MP14	5062-7397	4	MOUNTING KIT - HYBRID (2 used on 54520 and 54522)
MP15	5062-7398	4	HEATSINK KIT - HYBRID (2 used on 54520 and 54522)
INTERNAL CHASSIS PARTS			
B1	3160-0829	1	FAN-TUBEAXIAL
E2	54542-27601	1	CONNECTOR ASSEMBLY - PROBE COMPENSATION
E3	54542-26101	1	CONNECTOR - GROUND (front panel)
E4	1252-5338	1	GROUND - BANANA PLUG (rear panel)
H10	0535-0056	3	NUT-HEX M4 X 0.7 5MM-THK 7MM-A/F (CRT)
H11	3050-0893	1	WASHER - FLAT (CRT)
H12	0515-0374	18	MS M3 X 0.50 10MM-LG T10 PAN-HD
H13	54503-25701	4	NUT - HEX 1/2-28 (front panel BNC)(3 used on HP 54520A/22A)
H14	0380-0002	1	SPACER 0.25IN-LG 0.156IN-ID
H15	0515-1363	9	MS M3 X 0.50 5MM-LG T10 PAN-HD (disk drive, handle plate)
H16	0515-0430	2	MS M3 X 0.50 6MM-LG T10 PAN-HD (line filter/cable assembly)
H17	2950-0072	2	NUT HEX 1/4-32 .062 (intensity adjustment, front panel ground)
H18	2190-0027	2	WIL 0.256 0.478 0.02 (intensity adjustment, front panel ground))
H19	2190-0009	2	WIL 0.168 0.340 0.02 (HP-IB cable)

Replaceable Parts (cont'd)

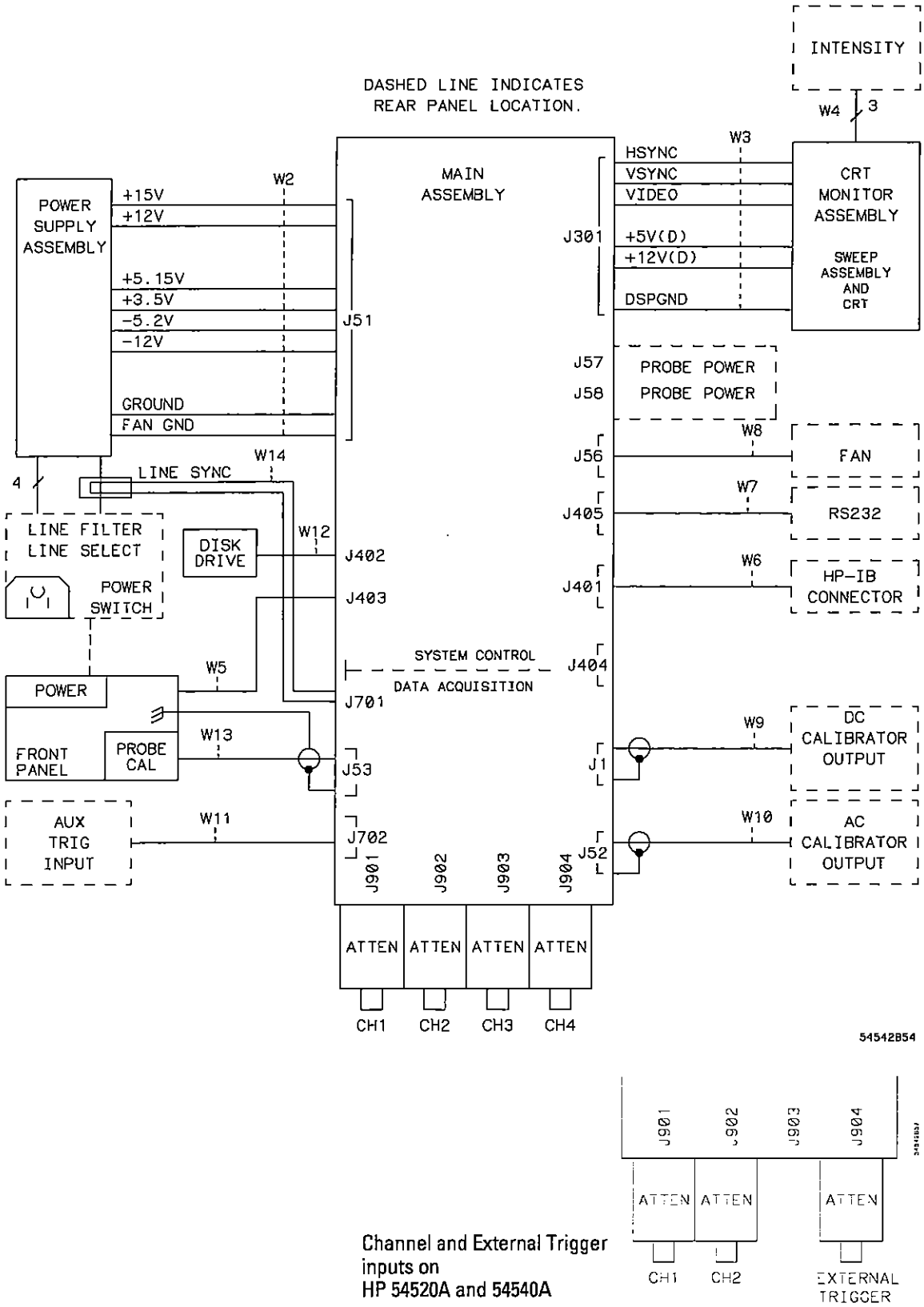
Ref. Des.	HP Part Number	QTY	Description
H20	0380-1482	2	STANDOFF-HEX 0.34IN (HP-IB cable)
H21	2190-0011	1	WIL 0.195 0.381 0.02 (probe comp connector)
H22	2950-0078	1	NUT-HEX 10-32 0.069 (probe comp connector)
H23	2190-0068	3	WIL 0.505 0.630 0.02 (rear panel BNC)
H24	2950-0054	3	NUT-HEX 1/2-28 0.125 (rear panel BNC)
H25	2510-0332	4	MS 8-32 0.7IN-LG T20 PAN-HD (fan)
H26	0515-0666	2	MS M3 X 0.50 XMM-LG T10 PAN-HD (keyboard spacer to keyboard)
H27	0515-0380	1	MS M4 X 0.7 10MM-LG T15 PAN-HD (CRT)
MP16			NOT ASSIGNED
MP17	54542-60001	1	CABINET ASSEMBLY
MP18	01650-01202	1	GROUND BRACKET
MP19	01660-01202	1	HANDLE PLATE
MP20	01650-46101	2	LOCKING PIN - POWER SUPPLY
MP21	01660-01203	1	BRACKET-DISK DRIVE
MP22	5062-7370	1	EXTENSION - POWER SWITCH
MP23	3160-0092	1	FAN GUARD
MP24	54542-00202	1	REAR PANEL
MP25			NOT ASSIGNED
MP26	1400-0611	1	CLAMP-CABLE (disk drive cable)
MP27	54542-04103	1	LUG PLATE (front panel probe comp and ground)
MP28	54522-41901	1	ELASTOMERIC KEYPAD (for 54520A and 54522A)
MP28	54542-41901	1	ELASTOMERIC KEYPAD (for 54540A and 54542A)
MP29	54542-45201	1	PANEL - KEYBOARD
MP30	54542-44701	1	SPACER - KEYBOARD
MP31	54522-94301	1	LABEL - KEYBOARD (for 54520A and 54522A)
MP31	54542-94301	1	LABEL - KEYBOARD (for 54540A and 54542A)
MP32	54520-94302	1	LABEL - CRT/LOGO (for 54520A)
MP32	54522-94302	1	LABEL - CRT/LOGO (for 54522A)
MP32	54540-94302	1	LABEL - CRT/LOGO (for 54540A)
MP32	54542-94302	1	LABEL - CRT/LOGO (for 54542A)
MP33	54542-94303	1	LABEL - BEZEL
MP34	54522-94304	1	LABEL - BNC (for 54520A and 54522A)
MP34	54542-94304	1	LABEL - BNC (for 54540A and 54542A)
MP35	5955-8032	1	LABEL - X-RAY
MP36	0380-1858	4	JACKSCREW WITH LOCK
W2	54542-61603	1	CABLE ASSEMBLY - POWER SUPPLY
W3	01650-61601	1	CABLE ASSEMBLY - RIBBON (monitor sweep drive)
W4	01660-61606	1	CABLE ASSEMBLY - INTENSITY ADJUSTMENT
W5	54542-61601	1	CABLE ASSEMBLY - RIBBON (keyboard)
W6	54503-61602	1	CABLE ASSEMBLY - RIBBON (HP-IB)
W7	54542-61605	1	CABLE ASSEMBLY - RIBBON (RS-232)
W8	01650-61616	1	CABLE ASSEMBLY - FAN
W9	54542-61602	3	COAXIAL CABLE (dc cal output)
W10	54542-61602		COAXIAL CABLE (ac cal output)
W11	54542-61602		COAXIAL CABLE (auxilary trigger)
W12	54542-61604	1	CABLE ASSEMBLY - RIBBON (disk drive)
W13	54100-61614	1	COAXIAL CABLE (probe cal/compensation)
W14	54710-61603	1	CABLE ASSEMBLY (Centronics)

8 Theory of Operation

8

Block-Level Theory 8–3
Power Supply Assembly 8–3
CRT Monitor Assembly 8–4
Main Assembly 8–4
Front Panel 8–4
Disk Drive 8–4
Attenuators 8–4
Attenuator Theory 8–7
Main Assembly Theory 8–7
Acquisition System 8–7
System Control 8–10

Theory of Operation



Channel and External Trigger inputs on HP 54520A and 54540A

Instrument Block Diagram

Theory of Operation

This guide supports troubleshooting to assembly level. Theory of operation for the main assembly is included as additional information. It is not comprehensive enough for component-level troubleshooting. The main body of following theory describes the HP 54542A. Differences in the other family models is covered at the end of the acquisition section.

Block-Level Theory

The HP 54542A Oscilloscope has four channels which are individually sampled at 2 GSa/s. Each channel is stored into 32 Kbytes of memory. The other instruments in this family have reduced specifications or features. The front panel provides:

- Several dedicated knobs and pushbuttons for major oscilloscope functions.
- Single-function keys, multifunction keys, and a knob for the remainder of instrument control.
- A 9-inch (diagonal) green phosphor CRT for information display.
- A 3 1/2-inch flexible disk drive
- A connection for probe compensation.

The rear panel provides several connections:

- The line power input.
- An auxiliary trigger input.
- The CRT intensity adjustment.
- An HP-IB connector for connection to a printer or controller.
- An RS-232 connection
- Two outputs, one for dc calibration and one for ac calibration or trigger out.
- Two power connections for active probes.
- A switch to protect the calibration factors.

The instrument consists of four major assemblies and four attenuators. Use the instrument block diagram on the previous page for the following discussion.

Power Supply Assembly

The switching power supply provides 120 W (200 W maximum) for the instrument. The ac input to the power supply is 115 V or 230 V, –25 to +15%. Maximum input power is 350 VA maximum. The ac input frequency is 48 to 66 Hz.

Unfiltered voltages of +15 V, –15 V, +12 V, –12 V, +5.2 V, and –5.2 V are supplied to the main assembly where they are filtered and distributed throughout the board and to other assemblies. The +5.2 V is adjustable on the supply.

CRT Monitor Assembly

The CRT Monitor assembly consists of the sweep board circuitry, a 9-inch green phosphor CRT, and the CRT yoke. The assembly requires +5 V and +12 V from the power supply via the main assembly.

The noninterlacing raster display is controlled by the CPU portion of the main assembly. System control provides synchronization and pixel information.

Main Assembly

The main assembly contains the acquisition system and system control circuitry. It provides interfaces for the attenuators, power supply assembly, CRT monitor assembly, keyboard, disk drive, HP-IB, and RS-232. The vertical inputs are the output of the attenuator assemblies. The auxiliary trigger input is directly to the main assembly through a cable from the rear panel. The user interface is through the front-panel keyboard or with a controller via the HP-IB connector on the rear panel. A more detailed theory of the main assembly follows block level theory.

Front Panel

The front panel is read and controlled by a microcontroller IC. This device contains a microprocessor, RAM, ROM, and a DUART for communication with the microprocessor on the main assembly. The microcontroller is located on the keyboard and communicates with the system control circuitry through a cable and RS-232 interface. It reads the keys and knobs and controls the LED indicators.

The elastomeric keypad has 48 keys: 17 single-function keys, 24 multi-function keys, and 7 softkeys with functions that depend on the displayed menu.

There are six knobs: five dedicated to specific functions and another that controls the function selected by the softkeys. Each knob controls a mechanical switch. The output of the switch is a 2-bit gray code that is read by the microcontroller for direction and distance turned.

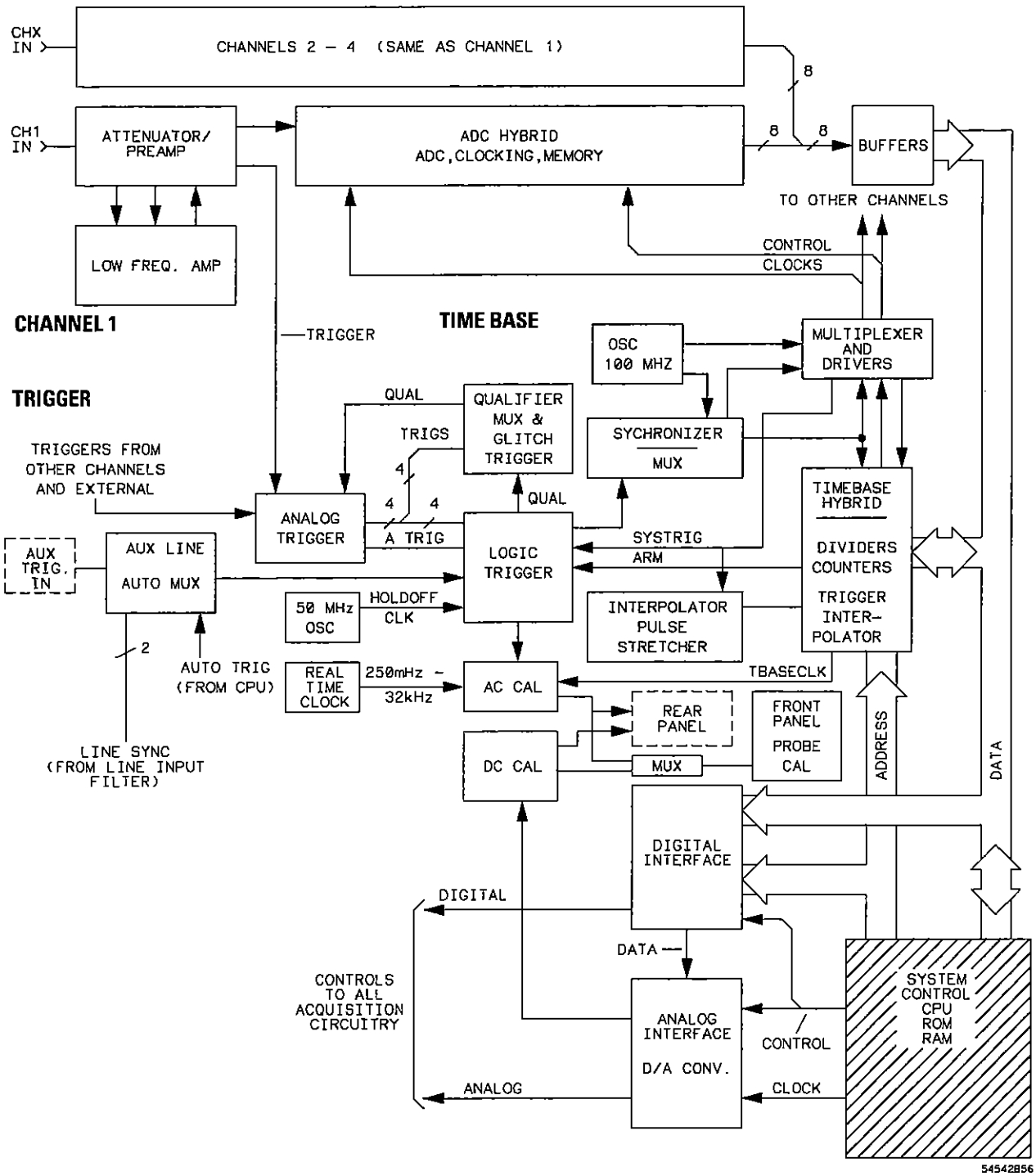
A pushbutton controls the power through a shaft to the line filter on the rear panel.

Disk Drive

The flexible disk drive is a 1.44 Mbyte and DOS compatible. It is located on the front panel. The disk drive can be used to load a new oscilloscope operating system into the flash ROM or load application specific software. It can also be used to store and recall instrument setups and waveforms.

Attenuators

The attenuators are the channel interface to the front panel. They provide the appropriate impedance matching and all the attenuation and gain changing. They connect directly to the main assembly and are fastened to the main assembly with screws.



Acquisition Block Diagram

Attenuator Theory

The channel input signals are conditioned by the attenuator/preamps, thick film hybrids containing passive attenuators, an impedance converter, and a programmable amplifier. The channel sensitivity, as displayed, defaults to the standard 1-2-5 sequence (other calibrated sensitivities can also be set). However, the firmware uses two passive attenuators, 5:1 and 25:1 to get attenuations of 1:1, 5:1, 25:1, and 125:1. With the attenuation and programmable gain of the amplifier the entire sensitivity range is calibrated. (On ranges below 7 mV/div, the firmware expands the signal digitally.)

The input has a selectable 1 MΩ or 50 Ω input impedance. Compensation for the passive attenuators is laser trimmed and not adjustable. After the passive attenuators, the signal is split into high-frequency and low-frequency components. Low-frequency components are amplified on the main assembly where they are combined with the offset voltage. The ac coupling and low-frequency reject are implemented in the low-frequency amplifier.

The high- and low-frequency components of the signal are recombined and applied to the input FET of the preamp. The FET provides a high impedance load for the input attenuators and a low impedance drive for the preamp. The programmable preamp adjusts the gain to suit the required sensitivity and provides two output signals to the Main assembly. One signal is the same phase as the input and goes to the trigger circuitry. The other is of opposite phase and is sent to the ADC hybrid.

Main Assembly Theory

The main assembly includes two major sections. One section is the acquisition system which conditions, stores, and processes the input signals. The other section is the system control with a 68020 microprocessor and 68882 coprocessor, ROM and RAM, and other associated circuitry. The main block diagram has been divided into two sections: acquisition and system control. The figure on the previous page is the acquisition block diagram and the figure on page 8-10 is the system control block diagram.

Acquisition System

The acquisition circuitry provides the sampling, digitizing, and storing of the signals from the channel attenuators. The four channels are identical. The auxiliary trigger input (from the rear panel) cannot be displayed. The trigger signals synchronize acquisition through the trigger and time base circuitry. A 100-MHz oscillator and the time base provide the base sample rates.

ADC Hybrid The ADC hybrid provides all of the sampling, digitizing, and high-speed waveform storage. The ADC includes a phase-locked loop frequency converter that, for sample rates from 250 MHz to 2 GHz, multiplies the input clock from the time base.

Trigger There are two main trigger circuits: Analog Trigger and Logic Trigger. Trigger signals from the channel and the external trigger attenuators are fed to the analog trigger. The analog trigger circuitry selects dc, ac, low-frequency reject, and noise reject (hysteresis) modes and sets the trigger levels. The analog trigger circuitry also selects the trigger for certain trigger modes such as edges and patterns.

The channel triggers and the selected trigger are sent to the Logic Trigger. The logic trigger provides the complex triggering functions, such as holdoff, delay, and pattern duration and range, as well as the interface to the time base.

The auxiliary trigger (rear panel) is compared to a trigger level in a separate circuit and then multiplexed with the line trigger. The auto trigger is combined with the selected trigger (aux or line) and fed to the logic trigger.

Time Base The time base provides the sample clocks and timing necessary for data acquisition. It primarily consists of the 100-MHz reference oscillator, time base hybrid, and trigger interpolator pulse stretcher.

- The 100-MHz reference oscillator provides the base sample frequency.
- The time base IC has programmable dividers to provide the rest of the sample frequencies appropriate for the time range selected. The time base uses the time-stretched output of the interpolator pulse stretcher to time-reference the sampling to the trigger point. The time base has counters to control how much data is taken after the trigger event (post-trigger data). After enough pre-trigger samples have occurred, the time base IC sends a signal to the logic trigger (ARM) indicating it is ready for the trigger event. When the trigger condition is satisfied, the logic trigger sends a signal back to the time base (SYSTRIG). The time base IC then starts the post-trigger delay counter. When the countdown reaches zero, the sample clocks are stopped and the CPU is signaled that the acquisition is complete.
- The Interpolator Pulse Stretcher is a dual-slope integrator that acts as a time-interval stretcher. When the logic trigger receives a signal that meets the programmed triggering requirements (SYSTRIG), it signals the time base. The time base then sends a pulse to the pulse stretcher. The pulse is equal in width to the time between the trigger (SYSTRIG) and the next sample clock. The pulse stretcher stretches this time by a factor of approximately 1000. Meanwhile, the time base hybrid runs a counter with a clock derived from the sample rate oscillator. When the interpolator indicates the stretch is complete, the counter is stopped. The count represents, with much higher accuracy, the time between the trigger and the first sample clock. The count is stored and used to place the recently acquired data in relationship to the trigger point.

AC Cal The AC Cal is a multiplexer circuit that provides several signals to the Probe Compensation/AC Calibrator outputs. The signal provided depends on the mode of the instrument. It provides a probe compensation signal, a pulse representing the trigger event, or signals used for self-calibration. The probe compensation signal is derived from the real-time clock oscillator and can be set from 250 mHz to approximately 32 kHz. The AC cal is sent through an analog multiplexer to the front panel for probe compensation.

DC Cal The DC Cal output is used for self-calibration. It is one output from a 16-channel DAC. The DC cal is also sent through an analog multiplexer to the front panel for probe calibration.

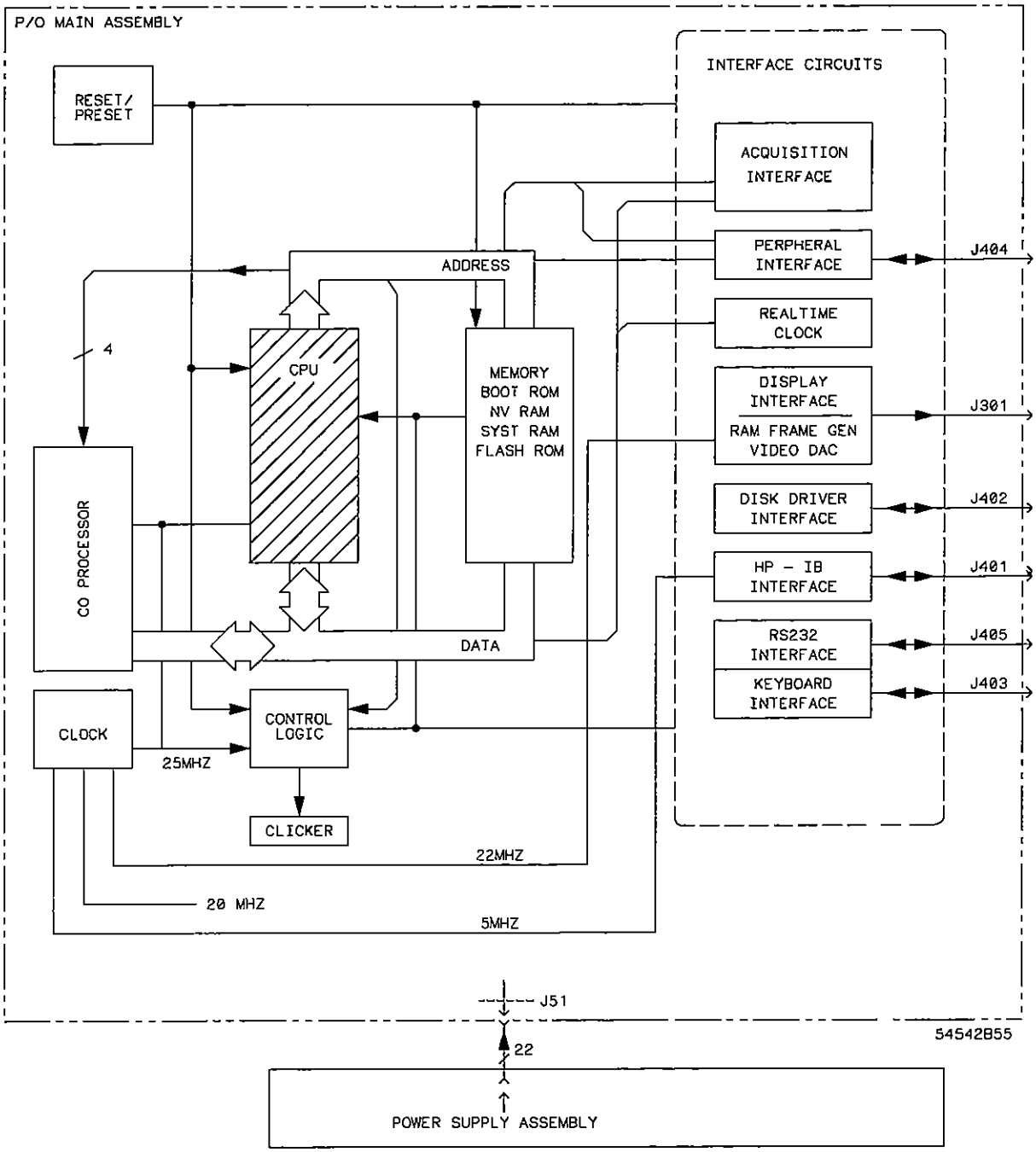
Digital Interface The Digital Interface provides control and interface between the system control and digital functions in the acquisition circuitry.

Analog Interface The Analog Interface provides analog control of functions in the acquisition circuitry. It is primarily a 16-channel DAC with an accurate reference and filtered outputs. The analog interface controls:

- Channel offsets
- Trigger levels
- Two logic trigger functions
- The DC Cal output for instrument and probe calibration

Family Acquisition Differences The following explains the differences in the three models that comprise the rest of this family, the HP 54540A, 54522A, and 54520A.

- The HP 54540A oscilloscope has four channels like the HP 54542A except that its sample rate capability is 500 MSa/s with four channels running and 1 GSa/s with two channels running. The acquisition architecture is identical to the HP 54542A.
- The HP 54522A has the sample rate capability of the HP 54542A, 2 GSa/s, but only two signal channels. The third channel position is unused and the fourth channel position is used for an External Trigger. The external trigger uses an attenuator/preamp for signal conditioning and has some of the ranging capability of a channel but no acquisition circuitry (there is no ADC hybrid). The output of the external trigger attenuator/preamp is fed to the analog trigger just like a channel.
- The HP 54520A has the two-channel configuration of the HP 54522A with 500 MSa/s sample rate capability on both channels.



System Control Diagram

System Control

The system control consists of the microprocessor, co-processor, ROM, RAM, and the interface circuitry needed to control the acquisition section and peripherals. Peripherals include the real time clock, display, keyboard, disk drive, RS-232, and HP-IB. The figure above shows the block diagram for the system control. The system control is the same for all models.

Central Processing Unit (CPU) The CPU is a 25 MHz 68EC020 microprocessor with addressing capability of 16 Mbytes (24 address lines/32 data lines).

A 25 MHz 68882 floating-point co-processor speeds computation intensive operations such as signal averaging, measurements and statistics, and waveform math functions.

Clocks Several crystal oscillators provide frequencies within the system control.

- The CPU clock is 25-MHz, derived from a 50-MHz oscillator. It drives the CPU and co-processor directly and, combined with other signals, clocks ROM, RAM, and other circuitry.
- A 22-MHz crystal oscillator clocks the display circuitry.
- A 20-MHz crystal oscillator clocks the 16-channel DAC directly. The 20 MHz is divided to 5 MHz to clock the HP-IB interface circuitry.
- A 24-MHz oscillator clocks the disk drive interface.
- A 3.6864-MHz oscillator clocks the keyboard and RS-232 interface.
- The real-time clock is clocked by a 32.768-kHz oscillator that is part of the clock IC.
- On the keyboard, the microcontroller is clocked by a 14.7456-MHz oscillator.

Control Logic The Control Logic provides timing and control for the system control. Primarily it consists of a programmed array logic (PAL) IC but includes other miscellaneous logic as well. Chiefly, it arbitrates between the various memories and peripherals for CPU time. The PAL is synchronized with the 25-MHz clock.

Clicker The clicker is the sound effect circuit. The clicker sounds when warning or error messages are displayed, when a key on the keypad is pressed, and (with some functions) when knobs are rotated.

Reset/Preset The reset/preset circuit provides the main assembly with a timeout during power up and power down. It consists of a voltage divider, reference voltage, and comparator. The timeout signal is used in critical time and power sensitive circuitry. The signal goes to the microprocessor, the control logic, decoders, and HP-IB and data acquisition interfaces.

When power is applied, as the +5 V supply crosses the upper threshold of the comparator, a timeout signal is generated and applied to the system control circuitry, assuring the board powers up in a known state. Similarly, when power is removed, as the +5 V supply crosses the lower threshold of the comparator, the timeout halts the microprocessor and resets all critical timing before the +5 V supply falls below the valid operating region for TTL.

Memory Memory for the system control is composed of Boot ROM, Flash ROM, nonvolatile RAM, and System RAM.

- The Boot ROM is a single 128K × 8-bit EPROM. Boot ROM holds the power-up firmware.
- The Nonvolatile RAM is CMOS static RAM organized as two sets of 128 K × 16-bits, 512 Kbytes total. The nonvolatile RAM stores front-panel setups, calibration factors, and nonvolitile waveforms. The nonvolatile RAM uses a lithium battery as power backup. When the supply falls below an acceptable voltage level, (during power-down) the lithium battery is automatically switched on and write protection is unconditionally enabled to prevent loss of data. Normal power-up of the instrument restores the calibration factors and menu configurations that were in effect before the last power-down. A key-down power-up, in which any key is held down during power-up, does not affect stored calibration factors, but does reset the menu configurations to the default settings.

- The System RAM is 4 Mbyte in eight 1M × 4-bit CMOS dynamic RAM ICs. The System RAM uses the conventional RAS/CAS timing scheme for read/write and refresh. System RAM stores variables, volatile waveforms, and is the waveform buffer.
- The Flash ROM is 2 Mbytes, in eight 256K × 8-bit EPROMS. System ROM is used to store system operating code. It can be loaded from the flexible disk drive.

Interface Circuits The System Control interfaces with two main functions: the acquisition system and the peripherals. The acquisition system includes the triggering, time base, attenuator/preamp control, and acquisition hybrids and their associated circuitry. The system control interfaces with the acquisition system through dedicated address and data buses. The peripherals consist of the real-time clock, keyboard, display, disk drive, RS-232, HP-IB, and a miscellaneous peripheral connector.

The peripherals have individual interfaces which are connected to the system control through the peripheral interface, a subset of address bus, data bus, and control lines.

- The acquisition interface connects the system control to the acquisition system. Through a dedicated interface, the system control provides data and address buses, control lines, and chip selects for acquisition circuitry.
- The real time clock is a dedicated clock IC with a crystal frequency control of 32.768 kHz. Time data is supplied to the CPU. A frequency divider network within the IC can be programmed to provide a set of frequencies that are available on the rear panel ac CAL output and the front panel Probe Comp test point.
- The keyboard interface is a DUART IC clocked by a 3.6864-MHz oscillator. The serial interface with the keyboard is two lines, receive data (RXD) and transmit data (TXD). The DUART receives the keystrokes and knob turn data from the keyboard microcontroller and transmits LED indications to it. The only other lines to the keyboard are 5 Vdc power and ground.
- The DUART that drives the keyboard is also used to drive the RS-232 interface.
- The display is driven by a video frame generator and one third of an RGB video DAC. The frame generator provides the vertical and horizontal sync and the video driver provides eight-bit gray-scale video. The video interface also includes the pixel RAM (256K × 8-bit DRAM) and the circuitry necessary to generate timing signals.
- The main parts of the disk drive interface are a disk drive controller IC and a 24-MHz oscillator for clocking.
- The HP-IB interface circuitry supports communication with other instruments (such as a printer, controller, or automated test equipment) The circuit consists of three main components. The HP-IB controller provides an interface between the microprocessor system and the HP-IB in accordance with IEEE 488 standards. An 8-bit data buffer and 8-bit control line buffer connect the HP-IB controller to the HP-IB bus.
  The HP-IB is a 24-conductor shielded cable carrying 8 data lines, 8 control lines, 7 system grounds, and 1 chassis ground.

Power The System Control requires +5 volts dc and +12 volts dc . System control supplies the display board with +5 volts, +12 volts, and display ground. The clicker circuit is operated from the +12 display voltage. The remaining system control circuitry is operated from the +5 digital voltage.

DECLARATION OF CONFORMITY

according to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name: Hewlett-Packard Company

Manufacturer's Address: 1900 Garden of the Gods Road
Colorado Springs , CO 80901
U.S.A.

Declares, That the product

Product Name: Digitizing Oscilloscope

Model Number(s): HP 54542A

Product Options: All

Conforms to the following Product Specifications:

Safety: IEC 348 / HD 401
UL 1244
CSA - C22.2 No. 231 Series M-89

EMC: CISPR 11:1990 /EN 55011 (1991): Group 1 Class A
IEC 801-2:1991 /EN 50082-1 (1992): 4 kV CD, 8 kV AD
IEC 801-3:1984 /EN 50082-1 (1992): 3 V/m
IEC 801-4:1988 /EN 50082-1 (1992): 1 kV

Supplementary Information:
The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC.

Colorado Springs, April 22, 1993

John W. Stoltzman

European Contact: Your local Hewlett-Packard Sales and Service Office or Hewlett-Packard GmbH, Department ZQ / Standards Europe, Herrenberger Straße 130, D-7030 Böblingen (FAX: +49-7031-143143)

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Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

Safety

This apparatus has been designed and tested in accordance with IEC Publication 348, Safety Requirements for Measuring Apparatus, and has been supplied in a safe condition. This is a Safety Class I instrument (provided with terminal for protective earthing). Before applying power, verify that the correct safety precautions are taken (see the following warnings). In addition, note the external markings on the instrument that are described under "Safety Symbols."

WARNING

- Before turning on the instrument, you must connect the protective earth terminal of the instrument to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. You must not negate the protective action by using an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.
- Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired fuses or short-circuited fuseholders. To do so could cause a shock of fire hazard.
- Service instructions are for trained service personnel. To avoid dangerous electric shock, do not perform any service unless qualified to do so. Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.
- If you energize this instrument by an auto transformer (for voltage reduction), make sure the common terminal is connected to the earth terminal of the power source.
- Whenever it is likely that the ground protection is impaired, you must make the instrument inoperative and secure it against any unintended operation. The protection is likely to be impaired if, for example, the instrument shows visible damage.
- Do not operate the instrument in the presence of flammable gasses or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.
- Do not install substitute parts or perform any unauthorized modification to the instrument.
- Capacitors inside the instrument may retain a charge even if the instrument is disconnected from its source of supply.
- Use caution when exposing or handling the CRT. Handling or replacing the CRT shall be done only by qualified maintenance personnel.

Safety Symbols

Instruction manual symbol: the product is marked with this symbol when it is necessary for you to refer to the instruction manual in order to protect against damage to the product.

Hazardous voltage symbol.

Earth terminal symbol: sometimes used in manual to indicate a circuit common connected to grounded chassis.

WARNING

The Warning symbol calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a Warning symbol until the indicated conditions are fully understood and met.

CAUTION

The Caution symbol calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a Caution symbol until the indicated conditions are fully understood or met.

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About this edition

This is the second edition of the *HP 54520 and 54540 Series Oscilloscopes Service Guide*. Edition dates are as follows:

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New editions are complete revisions of the manual. Update packages, which are issued between editions, contain additional and replacement pages to be merged into the manual by you. The dates on the title page change only when a new edition is published.

A software or firmware code may be printed before the date. This code indicates the version level of the software or firmware of this product at the time the manual or update was issued. Many product updates and fixes do not require manual changes; and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one-to-one correspondence between product updates and manual updates.

The following list of pages gives the date of the current edition and of any changed pages to that edition. Within the manual, any page changed since the last edition is indicated by printing the date the changes were made on the bottom of the page. If an update is incorporated when a new edition of the manual is printed, the change dates are removed from the bottom of the pages and the new edition date is listed on the title page.

All pages original edition